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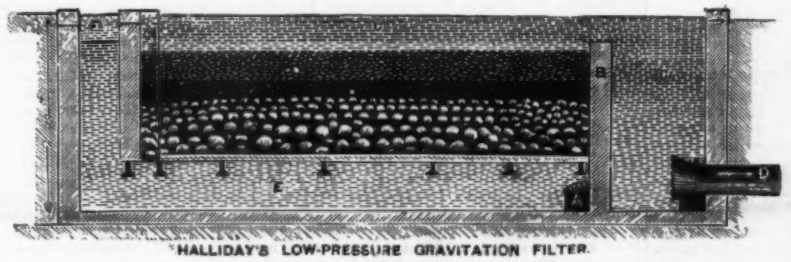
IMPROVED PRESSURE FILTERS.

THE engravings illustrate the installation of the high pressure self-cleansing filters made by Messrs. Joseph Halliday & Co., Manchester, and erected by them at Crewe for the London and Northwestern Railway Company, under the superintendence of Mr. F. W. Webb, M. Inst. C.E., chief engineer of the locomotive department. The *Engineer* thus describes them. Each filter consists of two cylinders, 4 feet diameter, 4 feet 9 inches deep inside, made of steel plates ⅜ inch in thickness. The bottom plate is dished, and is made of ⅝ inch steel plate. The top plate is ¾ inch in thickness, bolted to the cylinder with ¾ inch bolts, placed 2½ inches center to center. The interior of the cylinder is filled with animal charcoal of graduated sizes, as shown in the small engraving in the corner illustrating one of the cylinders in section. It will be seen that each cylinder is fitted with disks or plates to keep each size of charcoal in its proper place, the whole being fastened with stay bolts through the cylinder, screwed up at the top. The water enters from the left hand side of the filter through a four-way valve. This is to reverse the stream of water.

There is also a three-way valve similarly lined with gun metal, for carrying away the mud when the filter is washed out. The pipes and valve are 5 inches diameter inside. The four filters with eight cylinders receive the water from a 12 inch main at a pressure varying from 50 lb. to 70 lb. per square inch, and pass 40,000 gallons per hour of filtered water into a 12 inch main, as shown. The pressure in the supply and delivery main does not vary more than 1 lb. to 1½ lb., showing that the filters do not materially alter the pressure. They are, we are informed, working in every way satisfactorily. The space occupied by the four filters to deal with 40,000 gallons per hour is 40 feet long, 6 feet wide, 6 feet 6 inches high actual. A room giving ample space would be 45 feet long, 10 feet wide, and 12 feet high.

The low pressure or gravitation filter is illustrated by the accompanying section. It is for cleansing river water in large quantities, where space is available, and there is no artificial pressure. The water enters at F, and passes into the bottom, E, of the filter. It then passes upward through the filter bed and out over the wall, B, at the right hand side, filtered. The dimensions of the filter bed are of course determined by the quantity of water to be filtered. The filter is made in the simplest form and consists of a brick chamber, cemented to make it tight. It has two partition walls, as shown, and a perforated bottom is carried on girder or joist irons. A sluice valve is fixed under the filter bed at A, so that the filter can be flushed out at will. The wall, B, divides the unfiltered and filtered water, forming a reservoir for the latter at C. At D is the filtered water delivery pipe.



HALLIDAY'S LOW-PRESSURE GRAVITATION FILTER.

STEREOTYPING.*

By THOMAS BOLAS, F.C.S., F.I.C.

I.

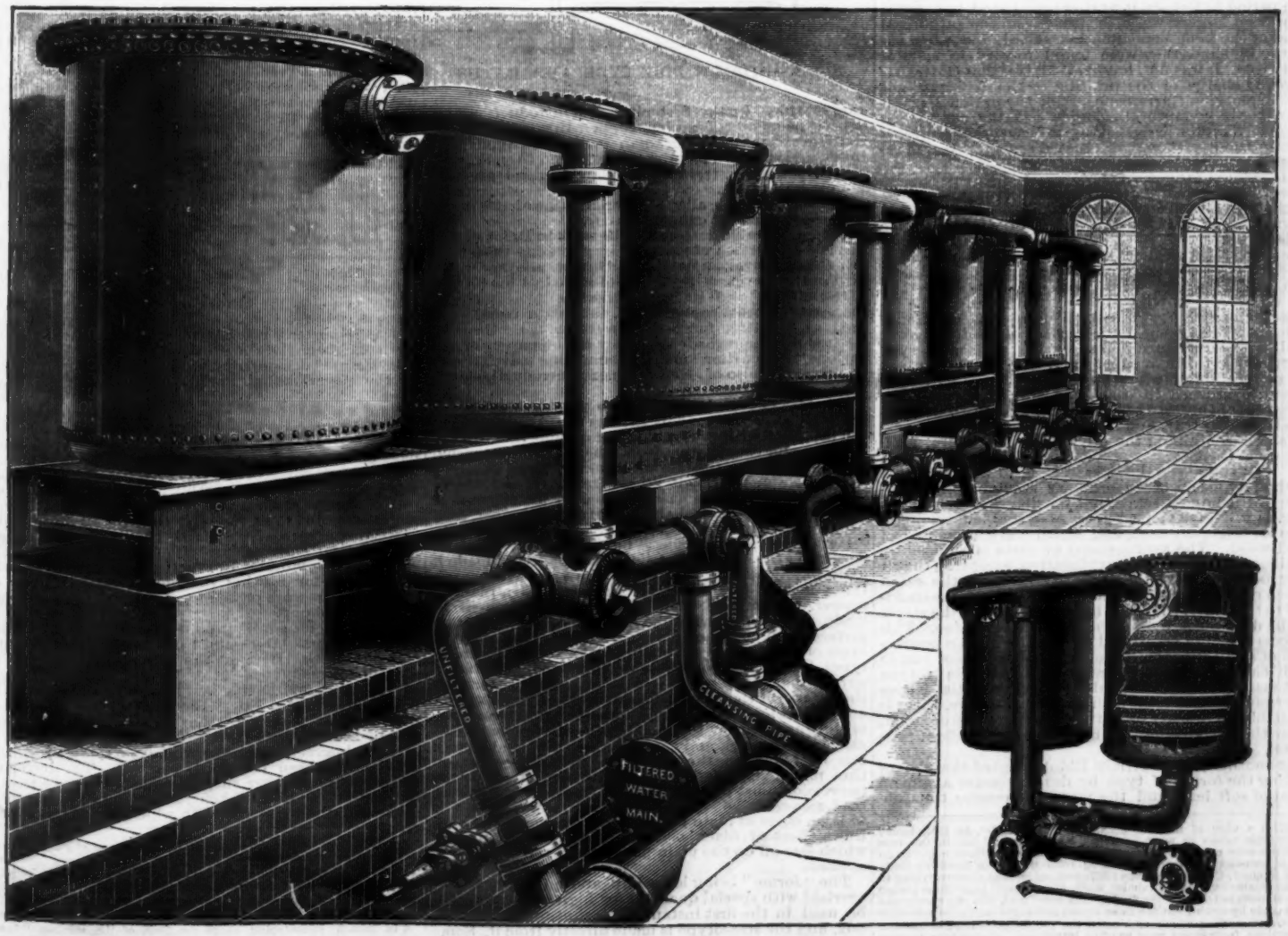
THE notion of casting from the assemblage of types, known to the printer as his "forme," seems to be nearly as old as the art of printing from movable types, a thing easily understood when one remembers that the art of fine casting in copper alloys was well understood four centuries ago, and the advantage of a solid page, not subject to fresh errors at the hands of every careless workman, must have been very obvious to those early printers, who tried so hard to eliminate errors of the press. Indeed, as regards the early history of stereotyping (in a copper alloy, such as brass or bronze) we may go back to the work of a Chinese stereotyper, who according to Skeen * labored very successfully about the year 1041.

The incentive to stereotyping in the early days does not appear to have been so much the multiplication of "formes" for the rapid production of copies, or the saving of type—for the old printers had very large founts—but the notion that mainly set the matter going seems to have been the desire to secure that accuracy of all copies which can never be depended upon when movable types are used for printing.

Accordingly we find that one of the first considerable uses of brass stereotype plates was for tabular matter, Gabriel Valleyre, a printer of Paris, having produced numerous calendar plates about the year 1700, the brass being cast in the clay or loam moulds. Valleyre's plates were small—about such size as one would use for foolscap octavo pages—and the sharpness of the letters was very much inferior to that of the type pages printed alongside. Still the brass plates answered their purpose to a certain extent, but the want of sharpness of such casts, and the difficulty of making large plates, were sources of trouble to a clergyman of Leyden, Jean Muller, who, with his son William, was endeavoring about this time to produce stereotype editions of the Scriptures (1700–1711). After numerous experiments in brass casting, this gentleman adopted the plan of producing solid pages, first by cementing the types together, and afterward by melting the types together at the feet; this latter process being a very easy one if the "forme" is locked up so as

* Lectures delivered before the Society of Arts, London, 1890. From the *Journal* of the Society.

* William Skeen, "Early Typography," Colombo (Ceylon), 1872.



IMPROVED HIGH AND LOW PRESSURE FILTERS.

to be thoroughly framed with the wooden furniture, and is placed on an iron surface which can be gradually heated to something short of redness. Muller was an enthusiast in his work, and he produced in this way a Syriac New Testament, a Greek Testament, and a Dutch folio Bible. The latter work was reprinted from his blocks as late as 1791, by Elwe, of Amsterdam, and some of his solid pages are in existence at the present time.*

The process of casting plates of type metal in plaster moulds appears to have originated with a goldsmith and money lender of Edinburgh, William Ged (1725), who was moved to experiment by a conversation with a printer, who told him a fortune would be the result of success in casting from the "forme." In a few days Ged managed to produce excellent casts, and set about looking out for the fortune which was to be the result. Ged and his sons seem to have spent most of their efforts during a period of about half a century in getting fresh partners and in quarreling over financial matters, with the result that they got no profit out of the transactions; but during this time many persons got hints as to their method of working, and the plaster process was experimented with in various parts of Great Britain. During this period (1740) Michel Functer, a printer, of Erfurth, stereotyped by the plaster process.

He made a paste by mixing—

Plaster of Paris	5 parts.
Crushed brick	2 "
Asbestos	1 "
Water enough to make a paste.	

This was spread on a slab, and the type "forme" was pressed into it, and when the mould thus obtained was dry, the type metal was poured into it. Functer published details of his method in the form of a pamphlet, but Ged—who seems to have worked in a very similar way, *i. e.*, by forcing the face of the forme against a soft bed of plaster, and not by pouring the mixed plaster over the forme—endeavored to keep his process secret.

Functer also described methods of casting type metal in sand moulds, the sand being bonded by linen or woolen fibers, and by the use of beer for mixing. To Functer belongs the credit of giving the plaster process of stereotyping openly to the world, and there is no record of the time when he commenced his experiments, or whether he knew of Ged's work.

The introduction of D'Arcet's fusible alloy, 1773—an alloy composed of bismuth, 8 parts; lead, 5 parts; and tin, 3 parts; and which melts below the heat of boiling water—was looked upon in Paris as likely to be of great service in stereotyping, but little was done with it beyond some experimental work.

About this time stereotyping was an established process, and was in regular use in several of the larger printing offices, especially on the Continent, and we find several persons publishing working details, notably Joseph Hoffman, who made moulds of plaster and clay, tempered with gelatine, gum, or starch (1783), while Andrew Foulis, of Glasgow (1784), was casting plates regularly, with the co-operation of Alexander Tilloch, of the same place. The stereotype books of Foulis are well known, and need no mention here.

Stereotyping methods were extensively employed in reproducing the small notes or *assignats* of the revolution period in France, it having been found impossible to prevent forgery while the designs on the authorized notes of the same denomination varied, and when engraved by hand they were found to vary in spite of every care. It was not, however, till 1797 that Gatteaux, who had charge of the printing of the *assignats*, got the stereotyping arrangements of the national printing office in good working order, and the method he adopted was one perfected by the celebrated printer Firmin Didot, although originated some few years previously by Joseph Carez, a printer of Toul.

According to this method, to which the name "polytype" was frequently applied, the page of type, or the original to be copied, is slightly oiled, and fixed face downward on a block of wood, supported, at some little distance, over a paper or cardboard tray, into which melted type metal has been poured. Just as the type metal begins to show distinct signs of solidification, the block carrying the page of type is allowed to fall on the soft metal, and on separating the two a reverse or mould is obtained. This reverse, or mould, being now fixed upon the lower face of the drop block, is allowed in its turn to fall on the surface of type metal contained in a paper tray, this metal being at the point of solidification as before. The paper tray is of course crushed in each case, and to regulate the thickness of the "strike," metal gauges are fixed alongside the paper tray, and in such position that the frame or chase containing the original, when down, shall rest upon them.

I will show you how easy it is to illustrate this method by means of an ordinary stamping press provided with a quick screw, but the diagram before you (Fig. 1) will give you an idea of a simple form of apparatus originally used, and which was constructed of hard wood. The arrangement of parts is sufficiently obvious without further explanation, excepting that it may be mentioned that the rod carrying the catch which releases the block should stretch from one standard to the other, the catch being taken out of the staple in the drop block by putting the wire in torsion. This process is still in occasional use for the rapid reproduction of small typographic ornaments or blocks, but in such cases the matrix is generally a thick electrotype cast made from the original block. For initial letters or ornaments about an inch and a half square, there is probably no quicker or better method of reproduction than that of striking the matrix into semi-fluid type metal.

At another period Firmin Didot adopted the plan of forcing the forme of type by dead pressure against a sheet of soft lead, and the matrix or reverse thus obtained served for obtaining printing plates by the method of striking into semi-fluid type metal just described. I will show you how easy it is to obtain a reverse in soft sheet lead by dead pressure, and also that if the lead matrix is placed in the ordinary stereotype casting box, casts may be obtained from it in ordinary type or stereotype metal, these alloys melting at a lower temperature than the lead.

In a similar way a lead matrix may be made by driving an ordinary type punchways into a piece of lead, and the lead matrix being adjusted to an ordinary hand mould of the right body size, it is easy to cast a number of types in it, which are about as good as the original; this being often a very convenient process to follow when a few extra types are wanted in a hurry.

In the usual casting operations it is generally necessary that the mould in which the casting is made should be of less fusibility than the material cast, although there are rare cases in which this does not hold good; but in the case of the striking method just described, we have a method by which an impression may be obtained in a much more refractory material than the original matrix. For example, an impression in sealing wax taken from type may be quickly driven down on the surface of type metal just on the point of commencing to solidify, and will yield a perfect cast in the alloy, and this I illustrate very easily by means of the quick screw press before used. Similarly, a die in high steel may be made from a silver or copper coin, if the steel is heated to bright whiteness, and the coin, attached to a drop hammer, is allowed to fall upon it. The main points to insure success appear to be forming of the steel block as a blunt cone, so that the middle shall first come in contact with the original, and the protection of the hot steel from the action of the air till the last instant. I have seen dies made by this process at the works of the Phœnix Die Company, of Prince's Street, Blackfriars, so perfect as to recall the smoothness and perfection of an electrotype, and I was told it was no uncommon thing for mints to send coins in order to obtain fresh dies for the replacing of injured ones.

The method of moulding by striking into soft metal is of great interest, and those interested in methods of typographic reproduction should bear in mind the possibilities of this method. If, for example, numerous small stereotypes in hardened steel were required, they could readily be obtained by the "striking" method, a steel die (itself, let us suppose, "struck" from an electrotype) being used.

Very much of interest and importance arose out of experiments carried on in the office of Firmin Didot, in Paris, about the end of the last century and the beginning of this. In the first place, the introduction of a hard type metal containing copper, this being due to Herhan, at the time a workman in the employment of Didot, and the hard metal was introduced to enable the type to stand the strain of moulding by dead pressure against lead plates.

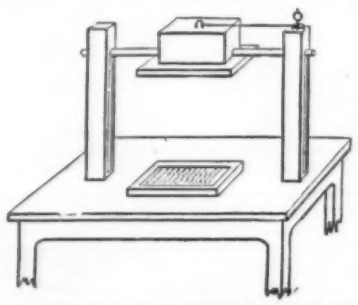


FIG. 1.—DIDOT'S POLYTYPE APPARATUS.

One of Herhan's alloys contained: Lead, 25 parts; antimony, 15 parts; copper, 6 parts.

Another notable outcome of the work in Didot's office was the production of a matrix by punching the letters into it successively, a device of Guillot, another workman in the service of Didot. Guillot called his process "Graphitype," and he drove the steel type punches successively into a copper plate, this plate being then used as a matrix for casting a stereotype. Guillot's method may be regarded not only as the parent of the various "type writer" methods of making matrix sheets or strips, but also of Herhan's next introduction—the use of matrix types.

It is easy enough to illustrate to you the principle of Guillot's "Graphitype" by driving these punches into the face of this copper plate, using a guide rule to keep the line, and then casting from the plate in the usual casting box. In this form, however, it is hardly a practicable method, but its modern developments, in which a kind of type writer is used to make a matrix out of wood (the end of the grain) or soft paper, may perhaps come into general use.

Herhan, whose hard metal has just been referred to, developed the idea of his fellow workman, and made it more practicable by setting up the page with matrix types instead of driving the punches into a plate of copper, this arrangement allowing corrections to be made, and also insuring that the whole of the printing surface shall be in one plane. Herhan's types were of brass or copper, and generally similar to the ordinary types, but in place of the projecting or male letter of our ordinary type was a female or matrix letter, just the reverse of the face of the usual type. Such letters, a few of which I have made and will hand round, are set just as ordinary types, excepting that they are arranged in the stick and chase non-reversed, and a proof can be taken on the press; preferably, however, on thin paper, such as is used for copying letters, as the impression must be read through the paper if it is to read non-reversed. Another way of taking a proof is to lay a sheet of plain paper on the "forme," and over this a sheet of black manifold paper, the coating of which sets off on the plain paper when the pressure is applied.

The "forme" being locked up, and any large whites overlaid with special quadrats (or high quadrats may be used in the first instance) it is shut up in a casting box, and the stereotype is made directly from it. Some of Herhan's matrix forms and casts were recently in the *Conservatoire des Arts et Metiers*, at Paris, and are probably still there. Didot issued several books printed from stereotypes made by this method.

The "Linotype" system of Mergenthaler, in which a very cleverly designed machine brings a number of matrices into a row, so that a line is cast, may be regarded as in some sense a development of the idea of Herhan, and before you are specimens illustrating the "Linotype" method, for which I am indebted to Mr. Thomason, the secretary of the Linotype Company.

Considering that in the case of newspaper work printing is always done from stereotypes, it seems to me that it would be a more reasonable and direct proceeding to set the matrices, and cast the required plate directly into the matrix forme, rather than to delay matters by the intermediate process of moulding. Although Herhan devised excellent methods of striking his matrix type quickly, and in true register, from the original punches, an engineer of the present day could do better. He could design a machine which would turn out brass or copper matrix types about as quickly as wire nails are cut off and headed, and the cost per pound of the matrix type possibly might not exceed that of ordinary types.

Again it is quite easy to make the matrix types radial, so that they can be "made up" in curved boxes, and plates for rotary machines cast as soon as the last lines are set or the final corrections made. On the table are a few radial matrix types which I have made. I cannot help thinking that the time is not far distant when Herhan's matrix type will largely replace those used now, and it need scarcely be said that the ordinary type setting and distributing machines would be as available with these as with the sort of type now in use. It certainly seems absurd to set a "forme," and mould a matrix from it, when it is just as easy to set up the matrix, and to cast directly into it.

Just at the beginning of this century we find A. G. Camus publishing a book on the methods of stereotyping, M. Camus being at that time responsible director of the printing of the French national currency, and he was required to be present whenever work incident to the production of notes was in progress. This work* gives very interesting details regarding the earlier stereotyping methods.

During the first decade of the present century, several English printing offices, including the two University presses, adopted stereotyping, and self-called "inventors of the process" went about, offering to sell or divulge the process for various sums from £20 upward. But in 1809, Charles Brightly, of Bungay, in Suffolk, published an English book giving full working details of the plaster process; the method described being practically the plaster process of the present time.† The plaster process of stereotyping was now established, and soon came into very general use for certain classes of work, and the next great step was the paper process, in which softened paper is forced down upon the original type "forme," and in the mould thus obtained one cast or more can be made.

In 1822, De Paroy, of Paris, published a small book ‡ describing in short form the leading stereotype methods, and calling attention to his own improved method, which method was not described, but only its advantages alluded to. In fact, this little book was evidently intended as an advertisement of the author's new and secret process of stereotyping, and from what he says about it, one may pretty confidently suppose it to have been the paper mould process, but in the absence of definite information, it would hardly be the thing to credit De Paroy with the invention of the paper process. We find, however, the method fully developed in a French patent by Genoud, of Lyons, in 1829, but there were certainly several persons making use of it before this time, and since then it has become essentially the stereotyping method, and has ousted all other processes, except for special work. Among other things it has rendered possible the modern newspaper, and the facility which it affords for rapidly producing any required number of curved plates, suited for rotary machines, has revolutionized printing as far as rapid production is concerned.

Moreover, the process is so simple and so easy that any person may, at a cost of a few shillings, produce small stereotype plates equal in sharpness and general excellence with those made in the most perfectly fitted establishment.

At this point my historical sketch is brought to a close, as what is to be said about the origin of later or less important processes may be left over till the methods themselves are described; but I purpose in this lecture demonstrating the essential principles of the paper mould method, leaving details until later.

Here is a pad of soft paper—it is built up of about twenty thicknesses of soft blotting paper—stapled together at the edges, and a hard impression from a page of type is taken upon this pad. It is now placed between two slabs of dry wood, which slabs are separated, to a distance of something under a quarter of an inch, in strips of the same material, and melted type metal is poured in at the top. On separating the slabs of wood, you see we have a fairly good cast of the original type, and the whole process of producing it has taken less than a minute. In practice, however, dry paper is not used for making the mould, but a number of sheets of paper are pasted together, and this combination is used damp.

Here are some sheets of paper—of the sorts and quality I will speak later—and I paste them together with this soft paste. Here, on the other hand, is the soft pasteboard ready made (it is known to the workman as "flong"§), and having laid it on a warm and slightly oiled page of type, I beat the back with a stiff brush until the soft pasteboard has taken a perfect impression of the face of the type. On the back I now lay a piece of blanket, pinch the whole in a screw press, the press having been previously warmed. The drying of the mould may under such circumstances take from a few minutes to half an hour, according to the temperature and the frequency with which the blanket and

* With a view of insuring accuracy, Firmin Didot, in 1794, issued logarithmic tables in what he termed "stereotype;" but in this case the types were merely cemented together in order that there might be no risk of introducing errors in working from them or in handling them. More recently, Charles Babbage (1827) took advantage of stereotyping to insure greater certainty in tabular work, his tables of logarithms having been stereotyped before the final proofs were read, and the corrections were made by cutting out the false figures and soldering in the necessary types, a proceeding which eliminated the old difficulty that, in making corrections, fresh errors were so often introduced. Corrections in these plates have been made from time to time, and an edition was printed last year by Messrs. Spon & Co.

* A. G. Camus. "Histoire et Procede du Polytypage et de la Stereotypie." Paris: Baudouin. An X. (1801.)

† "The Method of Founding Stereotype," by Charles Brightly. Bungay: 1809. Printed for Charles Brightly by R. Phillips.

‡ "Precis sur la Stereotypie." Par De Paroy. Paris, 1822. Imprimerie Stereotype de Cosson.

§ In French stereotyping shops the form of the word is "flan," flan being a thin farinaceous cake sold in Paris. The origin of the word would have been less obscured if we had retained the French spelling, and pronounced the word according to the English usage.

other packing is changed; but I have here a similar "forme" upon which is a mould already dry and warm. This being clamped between slabs of warm iron, metal is poured in, and a cast is obtained little if at all inferior to the original type in sharpness. Here, then, you have the essential features of the paper mould process, and the latter part of my lecture will be occupied with the details of this the most important of all stereotyping processes.

In the room there are numerous specimens illustrating stereotyping processes generally, and more especially the paper process; also apparatus and plant. Many of these things have been lent by leading firms; and although special reference to most of them belongs rather to the following lectures than to this evening's subject, I mention some of them now, and at the same time trust to the kindness of the lenders to allow them to remain for the illustration of subsequent lectures. Messrs. Richardson, Koolman, and Isger send a very extensive collection, which illustrates almost every branch of the work they carry out, and among the casts which they send is a curved stereotype of the special edition of the *Evening Standard* of to-day. Mr. James Dellagana, whose father was, I believe, the first to introduce the paper mould process into this country, sends a set of specimens illustrating the various stages of the method of stereotyping. Similarly, Mr. Plummer sends illustrative specimens of several processes.

Among the apparatus for stereotyping, the very complete and compact plant of Messrs. Harrild & Sons deserves special notice, also the portable foundry of Messrs. J. M. Powell & Son.

THE PAPER MOULD PROCESS.

Here is the page of type or "forme" which is to be moulded, and instead of being locked up in the chase surrounded with the ordinary wooden furniture, we have a type-high border about ⅜ of an inch wide around it, but the face of this type-high border does not come quite close up to the type, there being a space of ⅛ of an inch between them. This type-high border is ordinarily obtained by surrounding the forme with strips of type metal called "clumps," or "stereo-clumps," these clumps being type high, and about half an inch wide, but a bevel on the edge placed next to the type reduces the face width to about ⅜, and gives the clear space of about ⅛ of an inch or so between the face of the clump and the type.

The object of the clumps is to form a level bed for the strips of metal—commonly called "gauges"—which determine the thickness of the plate. The space between the type and the face of the clump leaves room for the saw cut if the plate is to be trimmed close, or for the bevel if the plate is to be trimmed for mounting with catches on a metal block.

Now the forme should be planed level, not too tightly locked up, and its face must be slightly but completely oiled, this being done by rubbing it with a flat brush, not too heavily charged with oil, the brush being about as stiff as an ordinary hat brush. The traditions of the craft ordain that the oil should be the finest olive oil. But as a matter of fact, neither olive oil nor cotton seed oil, which is now commonly sold as olive oil, is the most suitable, as these oils—and more especially the latter—are saponified very readily by any trace of alkali which may remain on the forme. A much more suitable oil is the very thin mineral lubricating oil which is sold retail at about 1s. 6d. a gallon.

Here is a case in which an article sold at the lowest price is the best, and in connection with stereotyping—as indeed with most industries—there are many such cases, so much so that one must look with suspicion on the common but vague instruction to "use only the very best materials." The practical interpretation of this is to use just those samples for which the shopkeeper chooses to charge the highest prices. And when such an instruction is given as generally applying to all materials used in a craft, one may perhaps reasonably suppose that it is given because the instructor's knowledge of the materials is too uncertain for him to specify what qualities are desirable. Generally speaking, the forme is slightly warm when oiled. If it is cold and damp the oiling is almost certain to be unsatisfactory, and the mould may adhere to the type.

We now come to a very important matter, the flong and the materials used in its preparation. First, let us take the paste used to cement the various layers of paper together, and as to this matter one finds in the usual instructions merely a confusing crowd of recipes without the smallest indication as to choice between them, and some of these recipes order the use of materials the special service of which it is very difficult to conjecture.

As an adhesive ordinary gum (arabic or acacia gum) is undesirable. It penetrates the substance of the paper, tends to make it unmanageably hard and brittle when dry, and, weight for weight, it gives less adhesion between sheet and sheet than is the case with starch or flour paste. Gum is especially bad in relation to the fine tissue which forms the face of the flong, as in penetrating this, it not only tends to adhesion with the type, but where the gum has penetrated, the face of the cast obtained will have a rougher texture than elsewhere. In addition, gum is expensive, and, what is perhaps worse, very variable in quality.

Starch paste is a very good adhesive, as its water principally penetrates the sheets, leaving the starch where most wanted, and that sponginess which is a characteristic of good and useful flong is retained.

Good as simple starch paste is, a paste made from a moderately glutinous flour, such as wheat flour, is better, as the gluten gives the starch greater consistency and adhesiveness without other disadvantages. Moreover, wheat flour paste is easier to prepare and to manipulate than starch paste, and if measured by adhesive power, is very much cheaper. Moreover, it penetrates the paper even less than starch paste. Altogether the advantage rests with wheat flour paste as the main adhesive.

Glue (the term includes gelatines and sizes) by itself is not a very suitable or desirable adhesive to use, as it is subject to the same disadvantage as gum arabic as regards penetration of the paper, yet in a lesser degree. But when used in conjunction with sufficient flour paste, the penetrating quality is eliminated, and owing to the setting of the glue, the flong acquires increased sponginess and also the valuable quality of being more rapidly compressed by the face of the type when the metal is warm, as the glue melts and consolidates the compressed parts. In addition, by the use of glue along with flour paste, the flong becomes capable of holding rather more water without becoming flabby, and where the flong is not compressed, it dries more spongy than would otherwise be the case. There is advantage in using glue with the paste, whether the type is to be moulded cold or warm, but very special advantage in the latter case. The sort of glue most suitable is the soft and degenerate glue sold retail in the oil shops at 4d. per lb., high priced hard glues and fine gelatines being very much less suitable. Instead of using glue, it saves time to purchase size, but care should be taken to use the low priced size sold as common size (14 lb. 1s. in London oil shops) and not the harder and finer size known as "patent size."

We may then dismiss all adhesives but flour paste and glue. The former can be used by itself, but glue by itself is not very satisfactory. Together they give the best results for reasons already stated.

It is desirable to mix some mineral matter with the paste, and for this use we find, among other additions, the following recommended: Whiting, litharge, white lead, kaolin, other clays, Paris white, zinc white, barytes white.

The use of the mineral matter is twofold. It makes the compressed parts of the mould more hard and stony than they would otherwise be, and less subject to blister or scale during drying or casting, and it makes the uncompressed parts of the flong more spongy and uniform in texture. At the same time it makes the whole mould more resistant of heat.

Of the above, the only very definitely objectionable substances are litharge and white lead, as, owing to the moisture and heat, the lead poison is specially liable to be absorbed into the system of the workmen. And of the rest, whiting seems to me the best, its softness of texture, fineness, and the ease with which it is compressed, enabling it well to fulfill the double function as stated above.

At any rate, I am quite sure that not one of the above is superior to whiting. Whiting, moreover, is cheap and easy to get.

We now come to the preparation of the paste. Into this iron pan I put:

Whiting	6 lb.
Water.....	20 lb. (2 gallons).

If the whiting is allowed to remain in the water for an hour or two, it will be found that the lumps have completely broken down, and the mixing will be easy, a point I can illustrate by mixing up a similar batch, which was set by to soak before the commencement of the lecture.

If, on the other hand, I try to mix this whiting which has only just been put in the water, it works into clots and becomes unmanageable. The hands form the most convenient tools for mixing the whiting and water, as also for working in the next addition:

Wheat flour.....	4½ lb.

This being thoroughly incorporated, the pan is set over the gas for the mixture to boil, it being constantly stirred with a wooden stirrer having a T-shaped head which can be kept in motion close to the bottom of the pan, and so eliminate all chance of burning. As soon as the mixture boils, the glue or size is added:

Soft size.	14	lb.
or		
Common glue.....	3½	"
Water.....	10½	" (a gallon and nearly half a pint)

The glue to be soaked in the water till quite soft.

In order to give the paste such keeping qualities as shall insure the mass keeping good for years, four ounces of phenol* (carbolic acid) are now stirred in, and all that remains to be done is to work the mixture through a sieve having about twenty meshes to the linear inch, or it may be strained through a piece of net.

Three sorts of paper are used in making the flong. First, a fine hard tissue paper for the face; second, blotting paper to form the porous body; third, stout and tough brown paper for the back, to give strength and to support the blows of the beating brush. It is of very great importance that the tissue paper which forms the face of the flong should be strong and fine in fiber, uniform in texture, and free from holes, all qualities which add to the expense of a paper, and any expenditure which secures the above is well bestowed, any economy on this score being bad policy. A tissue which becomes pappy and soft when in contact with the paste, or which allows its exudation through holes, may cause adhesion between the forme and the mould, with the attendant delays and disadvantages. The tissue papers sold for pottery transfers are generally very suitable for stereotyping, and some makers supply a special kind. The sort I am using is sold at Lloyd's paper office in Crown Court, at 11d. per lb., and it is made to a special size, 24 in. by 56 in., so as to be suitable for newspaper work.

As regards the blotting paper, the cheaper sorts answer as well as the more expensive, and I do not think the lowest priced papers contain irregularities or lumps so pronounced as to be disadvantageous. That which I am using is demy paper, weighing 23 lb. to the ream, and costing 10s. 6d. per ream.

The brown paper for the back of the flong should be made of tough, strong fiber, free from knots and lumps; moreover, it should be soft, and not heavily rolled. Such a paper is expensive, costing about 4d. per pound, but as in the case of the tissue, it is poor economy to use a backing paper of unsuitable character.

I will now prepare some flong. The materials being:

	Approximate weight in grains.
Brown paper (1 square foot).....	200
Blotting paper, 3 thicknesses (3 square feet).	355
Tissue paper (1 square foot)..... ...	25
	580

* The carbolic acid should be the tolerably pure white crystalline kind, usually sold in 1 lb. bottles, not the very crude, oily, and brown product used for pouring into drains.

The brown paper is laid flat and pasted uniformly by means of a rather soft, flat brush, the paste being by preference slightly warm, on account of the glue it contains, although with the above mentioned proportions it is possible (though undesirable) to work it cold. A sheet of blotting is now laid on, and the pasting is repeated between each layer of paper, but in the case of the last pasting, which holds down the tissue paper, only a small quantity of paste should be applied, and that as uniformly as practicable. A convenient way of laying down the tissue paper is to roll it on a wooden cylinder, and then to roll it off this on to the pasted surface; and all through the operation great care should be taken that no paste comes in contact with the outside face of the tissue; generally speaking, the wooden roller requires wiping after each use. Close contact of the several constituent sheets of the flong is best insured by laying a clean paper over it after each addition, and rubbing down with the hand, or with a cloth folded so as to form a pad. Hard rolling is best avoided, as it tends to lessen that sponginess which is so desirable a quality. If the paste has been applied in about the right quantity, the square foot of flong, the paper of which weighed about 580 grains, will, when wet and fresh, weigh about 1,400 grains, about 820 grains of this being paste; in this state it is too wet and too soft for convenient use, but if exposed to the air until something like 300 grains of water have evaporated—that is to say, until the square foot weighs about 1,100 grains—its consistency will be right for working. These weights are given principally in order that persons working from directions may be able to prepare a sample which shall have a convenient consistency, after which the remembrance of this sample should be a sufficient guide.

It is desirable to prepare the flong in the first instance with excess of moisture, and to allow this to evaporate spontaneously, as during this process of evaporation the paper swells and takes a plasticity and sponginess which is difficult to obtain in any other way. Moreover, the manipulation of making the flong is easier and more satisfactory when a soft paste, containing a full proportion of water, is used. If, however, one has occasion to prepare a piece of flong for immediate use, the best way is to employ as little paste as practicable. Quite apart from the question of the amount of moisture present, it is undesirable to make use of freshly prepared flong, as it is never so homogeneous as that which has been kept for some days. It may be kept in a varnished tin tray of the right size, a stout plate of zinc being laid on the top. Generally speaking, it is best to lay the sheets of flong face to face, as the backs are likely to have been soiled with paste. The paste should be kept from the face.

Flong prepared with the above mentioned paste will keep any length of time without decomposition or mildewing, but it may become partially or completely dry. This may be remedied by one or more dippings in water, with a full allowance of time for its absorption. When flong has completely dried it is rather a trouble to get it once more in good working condition, the best way being to dip in cold water, pile it in the storing tray, and keep this latter in a warm place, repeating the operations if necessary. Dry flong is an article of commerce, but it is more trouble to get it into good working condition than it is to start with the plain sheets of paper. It is often recommended to use two thicknesses of tissue paper on the face of the flong, and to interpose tissue between the several sheets of blotting paper, but these courses are open to objection, and, as far as my experiments go, have no balancing advantage. Two thicknesses of tissue on the face, with paste between, offer no greater security against paste reaching the type than does one thickness of tissue, and, moreover, for ease and rapidity of application, it is desirable to make the paste as fluid as practicable, and also to so work as not to involve the extra care and labor consumed in applying very thin layers of paste, and it is obvious that the larger the proportion of thin paper entering into the composition of the flong, so much thinner must be the layers of paste in order to obtain flong containing the same proportions of paste and paper. It takes much longer to spread a very thin layer than a moderately thick layer of paste.

Ease and quickness in working is generally on the side of moulding small formes rather than large, so that when work is sent in assemblages of many pages, it is often desirable to reimpose, so as to bring down the dimensions to demy folio or thereabout; but when large pages of close matter, such as newspaper pages, are concerned, the stereotyper has no option but to mould the forms as received. When several pages are imposed together for moulding, it is sufficient to allow a pica (one-sixth of an inch) between them, unless the edges are to be beveled; in which case quite twice as much space will be required to allow for the saw cut and two bevels. The type-high clumps, as before stated, surround the whole.

Sometimes the stereotyper will have to clean the forme himself, from the carelessness of the printer who sends it to him, and in this case it should be scrubbed over with a solution of the cheapest quality of caustic soda in water (one part of soda to about eight of water), well rinsed and dried. Here, then, is the forme, clean, dry, oiled, warm and resting on a planed slab of iron or "beating surface," heated from underneath, the heating being in this case by gas,* although in a factory it is often more convenient to use steam. The hand is now lightly passed over the face to detect any letter which may stand high, and the planer is brought into use if necessary.† All is now ready for the moulding. I take a piece of the flong, dust its surface over with powdered French chalk, taking care to wipe off all excess, then lay it face downward on the forme, and now comes the operation of beating.

The brush used for beating may vary in shape or weight, according to the habit of the workman, but the bristles must be good and closely packed, and the operation of beating is so similar to that of driving in a nail, that any person who is able to strike his nail every time in such a way that it shall be sent forward and without any tendency sideways, will probably make a satisfactory mould the first time; while one in

* The beating surface may be, and often is, an extension of the bed of the drying press (Fig. 2).

† The planer of the printer is a slab of hard wood, which is placed on the forme, and then struck with a mallet.

whose hand the hammer sways round uncertainly and uncontrolledly, hitting the nail at all sorts of angles, and perhaps even bending it, will not be very successful in making a paper mould from the type. In such a case it is perhaps better to educate the mind to the conditions necessary for successful hammering, by watchfully and painstakingly learning to drive drapers' pins up to the head in deal, than to waste flong and spoil type. The face of the brush must fall flat on the back of the flong, very little side driving being sufficient to shift the flong and spoil the sharpness of the mould; and a good plan is to first beat a line right across the page, and then to extend this first toward one end of the page and then toward the other. A

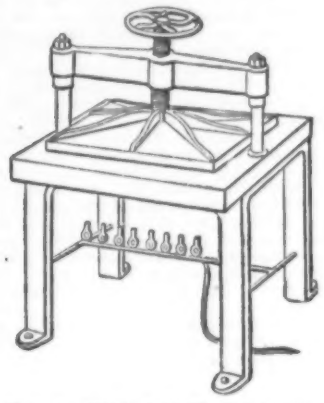


FIG. 2.—THE DRYING PRESS.

damp cloth is sometimes laid over the flong in beating, but if the brown paper is tough and nervy the cloth is not needed, and much time is saved by not using it—far more than is equivalent to the difference in price between good and bad paper. Moreover, when the cloth is used it becomes difficult to give such local treatment as is necessary on parts where words or rules stand almost by themselves, or where there may be a mass of small type closely set, to say nothing of the special treatment required where engravings are included in the forme. As a rough guide to the extent to which the beating is to be continued, it may be stated that with flong of the right degree of softness the divisions between the words set in long primer or brevier should show distinctly on the back of the flong. If the flong is very soft, the beating must not be continued until these divisions are so distinct as with normal flong; and if the flong is very hard, one will only obtain sufficient relief by making the divisions show very clearly.

The progress of the beating may always be seen by steadying the mould with one hand and turning back one corner, and the flong should always be so soft that this can be done without straining or stretching the part turned over. All this work of moulding by beating takes, as you may see, very much less time to do than to describe. Where there are extensive

FIG. 3.—THE BEATING BRUSH.

whites in the forme, the mould will be arched downward, and some support is needed in such places, or the arched parts would crush down by the weight of metal in the casting box, and much metal would have to be cut away from the plate. The usual way is to paste the back of the flong and to lay in the deep parts a few pieces of pasteboard or of old mould, after which a second sheet of brown paper is pasted and laid over all. A very gentle beating is now given to the mould, care being taken not to beat this last paper down into the hollows, as the main use of this sheet is to string or tie the domes and hollows formed in the main part of the flong.

Another way, more employed in newspaper offices, is to fill in the hollows with whiting, or dry plaster of Paris may be used; the pasted sheet of brown paper being laid over as before.

The impression is now sharpened up by planing. The printer's planer—which is a slab of hard wood—is placed on the mould and struck several times with the mallet. This should be repeated several times, moving the planer between times, and care must be taken not to shift or strain the mould sideways. Two or three thicknesses of blanket, or still better enough blotting paper to make up about half an inch in thickness, being placed over the mould, the forme and mould are pinched up in the drying press. (Fig. 2.)

A few words more about the beating brush. If the face is not level, or should become unlevel by use, it may be burned flat by contact with a plate of iron heated to a dull redness, and by the same means the edge and corners farthest from the handle may be very slightly sloped off, this making it more easy to give local treatment to any special part of the mould. Workmen who have skill and confidence in the use of the brush may strike tolerably hard, and they often find it a convenience to load the brush by fastening a plate of lead to the back. Some of the Continental workmen, instead of using a brush, prefer to use a wooden blank provided with a handle and covered with several thicknesses of soft cloth or "moleskin." Then, again, a rolling machine, or a vertical press, is occasionally used in making the mould, but the press and rolling machine are of little use except in the case of tolerably solid and uniform formes, such as the pages of a newspaper. The rolling machine for moulding consists merely of a moving bed with an adjustable cylinder over it, bed and cylinder being geared together. The machine, however, is seldom used without the brush being used as an adjunct. Sometimes the press or machine is used to set the flong firmly in position on the type, the brush being used for finishing, and sometimes the brush is used first, and the machine is employed to sharpen up the impression; to do what the planer does in the process of making a mould by hand.

A sufficient drying of the mould may be effected in as short a time as three or four minutes, in which case the heat is urged almost to the softening point of the type, or the heat may be more moderate, so that the drying takes as much as half an hour. It may, however, be taken that in the case of ordinary commercial stereotyping some water is invariably left in the mould; many hours baking at a temperature of 200° centigrade being necessary for the removal of the last traces of moisture. So that, when the best possible results are required, it is desirable (as I shall point out further on) to considerably extend the time allowed for drying.

In ordinary cases—the work not being subject to the extreme need of haste which exists in the case of newspaper stereotyping—the forme will remain in the drying press for ten or fifteen minutes, during which time the blanket (or covering of blotting paper, as the case may be) may have been changed two or three times, or if this is not done, the press should be undone, and the covering turned over to allow the more ready escape of moisture. All this time the bed of the press may be conveniently heated to a temperature from 160° to 190° centigrade; the former being about the degree of heat obtained if the bed forms the top of a steam chest, fed with waste or exhaust steam, but if "live" steam of about 30 lb. pressure is used, the temperature will be something like 130°.

Now let us return to our forme and mould. The mould leaves the forme at once. When any adhesion occurs, something is wrong with the work, and this must be obviated in future,* but a slight tendency to adhere can generally be combated by repeatedly lifting the edges of the mould as far as is possible without bending or straining the mould, and then letting it spring back; at the same time slightly loosening the quoins and beating the back of the mould with the brush will assist. In the case of persistent sticking, the only alternative is to heat the forme once more and repeatedly moisten the back of the mould with water. In this case the mould will be spoiled.

The mould, as it comes off the forme, is dry to the touch, but ordinarily not dry enough to give a good cast, and before drying it further it is convenient to trim the edges to the outsides of the gutters left by the clumps, and paste† on to one end of a flap of brown paper long enough to project two inches or so out of the casting box, and at the same time, to allow a head of metal of not less than six inches.

The mould may now be laid on a hot surface to further dry, or better still, it may be baked in a steam or gas oven, heated to about the same temperature as the moulding press; but in any case it should be kept flat by placing over it a piece of heavy but small meshed wire net,‡ and if necessary a weight is put upon this. The wire net should be in contact with the tissue paper side or face of the mould, as slight indentation on this side will do no harm, whereas any indentation on the back of the mould will show on the face of the cast; and when several moulds are piled in the oven for baking, they should be laid back to back and face to face, with a piece of sheet metal (say stout tin plate) between the backs, and one of the wire net sheets between the faces.

The baking, or second drying, being at an end, we come to the casting, and before this is done it is a very common practice to brush some finely powdered French chalk into the mould, and then to dust out the excess by turning the mould face downward, and gently beating the back with a flat slice of cane. This is quite unnecessary if the mould is very dry; but by the use of French chalk the effect of any trace of moisture remaining in the mould is minimized, and, moreover, the cast separates from the mould more easily—a matter of some importance when it is wished to make several casts in the same mould.

(To be continued.)

NIGRISINE.

THE *Moniteur de la Teinture* contains an article by Beaumann concerning this new coloring matter, and we give below the results of Beaumann's studies upon the use of this color. Nigrisine, the new basic gray, was discovered by Ehrmann, and is furnished to the trade by the St. Denis Company; it has just appeared on the market. It is in the form of a black powder, perfectly soluble in water, acetic acid, and muriatic acid. Nigrisine dissolves in water with a reddish gray color, which is changed to grayish blue by the addition of acids. It will find employment in printing and dyeing on account of its purity of shade, its good coloring power, its fastness, and the variety of shade which can be produced by mixing it with other basic colors which can be applied in the same way. It furnishes dark and light grays of great purity. The two following receipts are given:

	Dark gray.	Light gray.
Nigrisine	4 parts.	1 part.
Acetic acid 6° B	20 "	20 parts.
Water	30 "	25 "
Gum water	51 "	50 "
Tannin	8 "	2 "
Tartaric acid	1·5 "	1·5 "

The shade can be made heavier and bluer by increasing the proportion of tartaric acid, but with the risk of attacking the fabric, if the cloth is weak. This acid dissolves well in tannate of nigrisine, even in the presence of an excess of tannin. Another property of this color renders it capable of being fixed upon bleached cotton directly. A steam color made with nigrisine and without tannin gives a very good result. Reddish grays are thus obtained; they are less beautiful than, but are as fast to soap as, those made with tannin. The following receipt, which does not contain tannin, can be used:

Nigrisine	4 parts.
Acetic acid 6° B	20 "
Water	35 "
Gum water	50 "
Tartaric acid	1·5 "

After steaming, wash strongly, and soap. The color can be still more firmly fixed in this case by chroming after steaming and then soaping. This formula gives equally good results upon cotton, silk, and wool. Nigrisine will dye bleached cotton directly. For dyeing, use 1 to 3 per cent. of color, which will give full shades. It is necessary, however, to acidulate the dye bath with little acetic acid. This blues the shades. The color takes well upon cotton mordanted with tannin and tartar emetic, as is usually the case with basic colors. Nigrisine can also be used for padding, the goods to be dried by hot air, and then steamed, or the color can be fixed as follows: After padding, pass the goods, without drying, through a bichromate bath containing one-half of 1 per cent. of bichromate, at a temperature of 180° F.; an insoluble chromate is formed in the liquid. Nigrisine will take upon bleached cotton, even in the presence of muriatic acid. This color will certainly find lasting employment. In fastness to soap and to light, in easy application, and in cheapness, it leaves little to be desired, particularly if compared with the grays previously known.

ARTIFICIAL SILK.

MR. VIVIER'S new method of making silk out of cotton or wood cellulose, which, it is thought, bids fair to rival the already well known process of M. Chardonnet, is described at length in the columns of *La Revue Industrielle*. The material is obtained by heating tri-nitro-cellulose, obtained by alkalization and nitrification of cotton, with a mixture of acetic acid and gelatine, or other equivalent reagents. This material is transformed into pure filaments, which are a little less tenacious than natural silk, but quite as lustrous, and cost, according to the inventor, about sixty-eight cents per kilogramme, or about thirty-two cents per pound of yarn. The first part of the process consists in the economical and rapid manufacture of pyroligneous acid, from which is then easily extracted the crystallizable acetic acid necessary for the elaboration of the filaments. The succeeding processes are three in number:

1. The preparation of the tri-nitro-cellulose.
2. Its treatment by acetic acid.
3. Its treatment by the reagents which convert it into silk, or, to be more exact, into a silky material which must then be transformed into silk again.

Taking these processes in their order we have:

1. THE PREPARATION OF THE TRI-NITRO-CELLULOSE.

This comprises two operations, alkalization and nitrification. The alkalization of the cotton is effected by treating it with an ammoniacal solution of caustic soda.

For this purpose, four kilogrammes of caustic soda are dissolved in twenty liters of water, and to this solution, after it has cooled, are added ten liters of commercial ammonia at twenty-two degrees Be. One kilogramme of cotton is steeped in this solution of ammoniacal soda for three days and three nights and stirred once a day. The cotton is then pressed and washed in water up to complete neutrality. It is next carded, after drying, in order to open the fibers so as to prepare it for nitrification. Nitrification is effected in an apparatus with a capacity of about 120 liters. This apparatus is charged with about twenty kilogrammes of saltpeter, dried at forty-five degrees, on which are poured, at two or three times, thirty kilogrammes of pure sulphuric acid at sixty-six degrees Be., the mass being stirred until the ingredients are thoroughly mixed. It should then have a temperature of eighty-five degrees. Into this liquid, at this temperature, tufts of cotton are introduced in small quantities. The apparatus is closed and made to revolve, with a double revolution, round its horizontal axis, and round its vertical axis, for five or six minutes. Then it is stopped, the lid is lifted, and the material dropped into a tub of water. After washing and drying in an oven, the nitrated cotton is ready to be used for the preparation of silk.

2. THE TREATMENT BY ACETIC ACID.

Three solutions are prepared:

a. A solution of gutta percha in sulphide of carbon.

b. A solution of isinglass in crystallizable acetic acid.

c. A solution of tri-nitrated cotton in acetic acid.

These solutions are mixed cold, so as to obtain a final solution in which the pyroxiline or tri-nitrated cotton forms seventy per cent., the isinglass twenty per cent., and the gutta percha ten per cent. To this is added a very small quantity of glycerine or castor oil, and the whole is blended together in a mixing apparatus. After this mixing process, the material is twice filtered, first roughly, and then more delicately.

3. ITS TREATMENT BY REAGENTS, WHICH CONVERT IT INTO SILK.

There has been obtained, by the preceding methods, a semi-fluid viscous substance, which is made into a filament, under water, by driving it through a small orifice. The thread thus produced passes, with the aid of appropriate machinery, through the following described six chemical baths:

a. A bath of soda to remove the excess of acetic acid.

b. An albuminous bath (of 3 per 1,000), to make the fiber supple.

c. A bath of bichloride of mercury (25 per 100), to coagulate the fibers. The coagulation is accelerated by passing the material afterward through an atmosphere of carbonic acid.

d. A ten per cent. solution of ammonia.

e. A bath of sulphate of alumina, which impregnates the fibers with a deposit of alumina. These last two baths are intended to lessen the combustibility.

f. A second bath of albumen (3 per 1,000) to render the fiber supple.

The proportions can be varied to a certain extent, or even replaced by equivalents, according to the par-

* Tissue paper not impervious; excess of paste under tissue paper, thus breaking up tissue; tissue broken in beating, from too hard blows or extreme softness of flong; mould too deep, so as to fit over the shanks of the types, or even penetrating between them; paste on face of the flong, from careless making or piling; imperfect oiling of forme, or unsuitable oil; alkali or other foreign matter on type.

† For this purpose a more adhesive paste is required than that used for making the flong. Stiff rye flour paste is best.

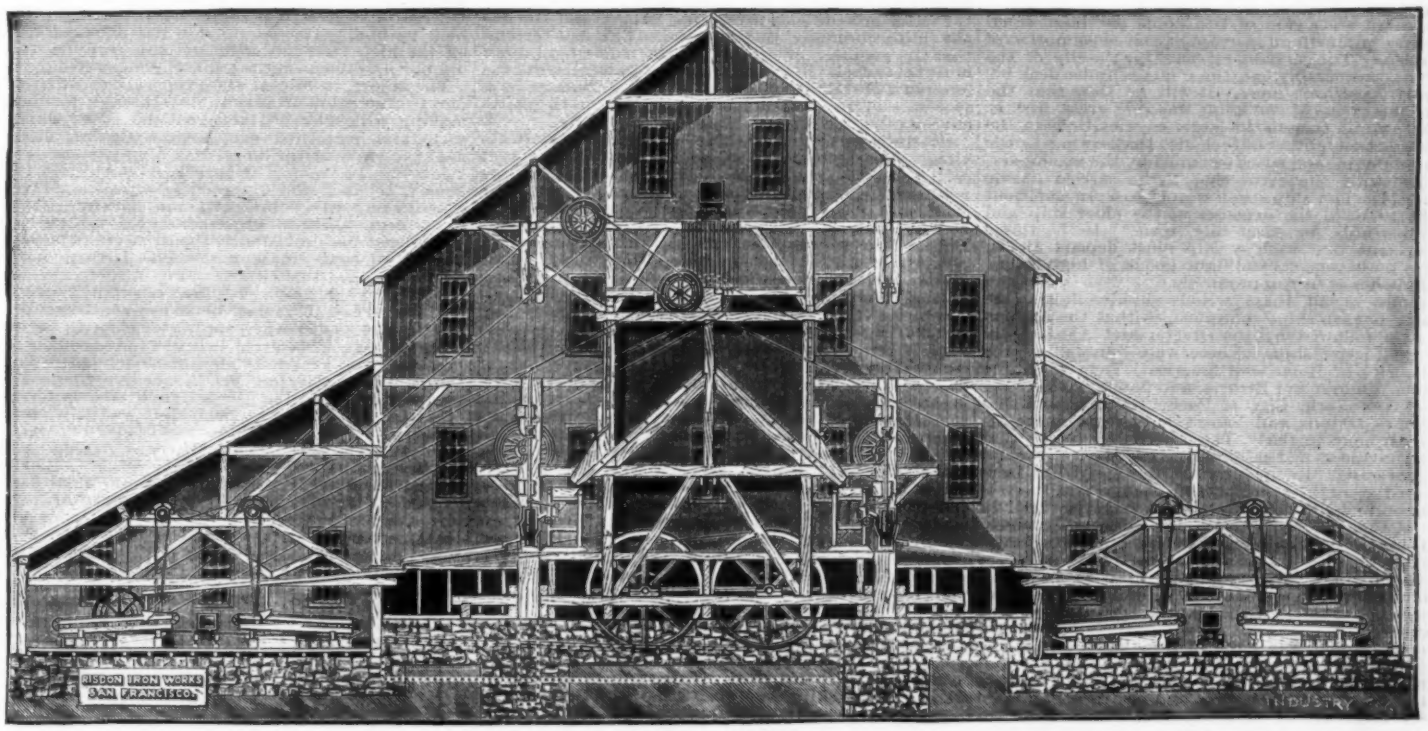
‡ A suitable wire net is made with iron wire of No. 16 L.W.G. (0.064 in. diameter), and six meshes to the linear inch, and can be had from firms that furnish miller's plant. The ordinary wire gauze or net sold at the hardware shops, having six meshes to the inch, is made of much thinner wire, and is not much use for our present purpose, as it has not sufficient rigidity to keep its shape as a slab or plate.

ticular results which it is desired to obtain. The filament which remains, after this series of chemical processes, is now wound upon a drum, before which a carriage is made to travel by means of a worm. This carriage is provided with burnishers, which polish the thread, and with guides, which insure its regular arrangement on the drum. When the drum and its fiber have been dried in a stove, the latter is carried to the winding machine. The bobbins of fiber thus obtained are next carried to the twisting machine, where the yarn is formed by twisting together a number of filaments sufficient to constitute a thread. The filaments on the bobbins, which are reeled as they turn round their common axes, are twisted into one single thread, before reaching the drawer, which takes the thread to the reel. The shafts are hollow, so that, if desired, a liquid jet can be projected on the thread as it is forming.

In connection with the above, a short account of the way in which another distinguished inventor, M. Fremy, proposes to meet the very great difficulty connected with the use of all silk of this kind, namely, its tendency to blaze up like gun cotton, owing to the presence of the nitric compound, combined with the cellulose, is also interesting. This nitric compound is eliminated by M. Fremy in the following manner: The vegetable silk is treated cold, with a dilute solution of the sulphohydrate of ammonia. The nitric element in the tissue is thus rendered soluble in water, and is entirely absorbed by the sulphurous compound. The fibrous cellulose principle remains in the insoluble state, and can be purified simply by washing in cold water. This action of the sulphohydrate of ammonia on vegetable silk is so rapid that it is complete in a few hours, and so thorough that the resultant fiber does not burn more quickly than threads of cotton. The denitrated silk preserves all its original properties. It is tenacious, it is as glossy as the purest silk in the market, and is not more inflammable than cotton yarn.—*Amer. Silk Journal.*

THE ALASKA MILL—THE LARGEST QUARTZ MILL IN THE WORLD.

THE largest quartz milling plant in the world is that of the Alaska M. & M. Co., Douglas Island, Alaska. It has 240 stamps of 850 lb. each, six rock breakers and ninety-six concentrators, and is capable of reducing 600 tons of ore in 24 hours. The mill is driven by water-wheels during the wet season, and there are steam engines for use when water runs short. Each plant has 400 horse power. This mill was built by the Risdon Iron Works, of San Francisco, and was at first 120 stamps, but this number was subsequently doubled. The cut on this page shows a cross section through the mill.—*Min. & Sci. Press.*



THE 240-STAMP MILL OF THE ALASKA MILL AND MINING CO., DOUGLAS ISLAND, ALASKA.

THE DEVELOPMENT OF THE MARINE ENGINE, AND THE PROGRESS MADE IN MARINE ENGINEERING DURING THE PAST FIFTEEN YEARS.*

By A. E. SEATON, M.I.C.E., M.I.M.E., M. Council, I.N.A.

IN this paper it will be my endeavor to trace the development of the marine engine and its appurtenances, and the general progress that has taken place in marine engineering generally during the past fifteen years, rather with the object of attributing much of it to the successful efforts of the members of this Institute in their various capacities, and thereby to render my thanks to them for the very valuable service they have contributed to my profession, than to tell of what has been achieved by the skill, ability, and perseverance of my colleagues in shipbuilding and engineering.

The engineer has been at all times dependent on the ironmaster, and on more than one occasion his progress has been barred by the inability of the latter to overcome some obstacle to success in his manufacture; but, on the other hand, it is equally true that the ironmaster has often been ahead of the engineer, and has been prepared, long beforehand, to supply that which would make a success for the marine engineer, if he would avail himself of it.

That eminent engineer and most fruitful of inventive geniuses, Trevithick, who a century ago saw instinctively what was possible with steam at high pressure, had to resort to sorry contrivances to try his experiments with the force which he knew would be so useful. His boilers, made of copper tubes in granite tube plates, now might serve as a monument to his genius, and as an example of the straits to which he was by the circumstances of his time reduced, rather than as a proof of his ingenuity. It is true that since his day the tube or tubulous boiler has been employed successfully to generate steam of high pressure, and that therefore the boiler in question might be taken as another example of his prescience. It is nevertheless a fact that he did not succeed until the ironmaster of his day gave him iron plates, or, as we would be disposed to call them now, very broad bars. The dilemma that arose as to the shaft of the Great Western was removed by the genius of Nasmyth, an engineer; but the steam hammer with out the men to work a forge would have been a useless tool, and the cast iron shaft would have had to take its chance; so that I infer that as much skill and invention were shown by those men who had to manipulate the iron with that hammer for the first time as was required to conceive, design, and make the hammer itself. History has not therefore been quite fair, for although she has recorded the one feat, and has justly recorded her tribute of praise to the inventor of the tool, so far as I am aware there is neither name nor praise recorded of the men worked it, nor of the ironmaster who erected it. I do not mean to say that the circumstances are not known, but there are now very few men who could give the information, and although only a comparatively short time has elapsed, their names are practically forgotten.

On the introduction of Siemens steel plates the old Staffordshire list of extras was practically abandoned by steel makers. This had more to do with the progress subsequently made in boiler construction than the introduction of the material of superior strength, inasmuch as it made it possible to construct a boiler with the minimum number of plates at a less expense than one with almost the maximum number. The ironmaster could give us plates nine feet wide twenty or more years ago, but he wanted such a high price for them that no boiler maker who worked in competition with his neighbors had the courage to use them, although I am of opinion that it would have paid to do so in all districts where labor was high. And that the boiler maker did not use them was rather in consequence of his inability or disinclination to reckon the cost. At any rate, he did not employ large plates until they were practically the same price as small ones, and so boilers were constructed in the patchwork form until the era of Siemens-Martin steel. Here, as usual, it was the bugbear of cost that stopped progress, and this same bugbear does to this day often bar our way to the goal that some of us see so far off. You, gentlemen, have often proved yourselves to be our saviors, and we always look to you to remove the obstacles to progress that confront us, as also to the development of new departures. Without your help we would be at a standstill; with it we can advance step by step; and I am bound to say, in justice to you, that when we make clear our demand for some new thing, you always tackle the problem forthwith, and sooner or later give us what we need. We have not yet, however, exhausted the list of things we want, nor have you yet satisfied all our longings for the things we have asked for. When you give us steel castings without blowholes, steel forgings absolutely free from hair marks an eighth of an inch below the surface, steel plates that know nothing of the "blue black" state, and that will not give way under any circumstances at a less strain than that to which they have been tested, we will be not only very grateful to you, but will ask for something else that shall give you the enjoyment of exercising your inventive genius and that splendid patience with which I know you are all endowed.

The period chosen for consideration in this paper is one that embraces the genesis of the modern development of the marine engine and boiler, but it is, moreover, the time that has elapsed since the introduction of Siemens steel, to which I attribute much of the progress that has recently been made. Prior to that time, iron was used almost exclusively in the construction of marine boilers, and very little steel indeed had been used in the engine. Boiler shells were made of Staffordshire iron plates, or of such other iron as was equal to it in both quality and price; the insides, such as the furnaces and fireboxes, were made wholly or nearly so of what was familiarly known as "Lowmoor quality." The price of the latter was very high compared to that of the steel we now use, and may be taken as £30 per ton on the average. The Staffordshire iron would at that time average about £9 for a boiler made of comparatively small plates, and £12 for a boiler made by a more enterprising engineer with larger plates. There was practically no limit to the boiler pressure so far as the internal parts were concerned, but the working pressure was decidedly limited, in so far as it was governed by the shell. There were then some few firms that could supply a plate 1¼ inch thick of fairly large dimensions, and in some very few instances plates as thick as 1¼ were used. Taking the former as the most common and also the most convenient thickness, it meant that a boiler 15 feet diameter would pass only for a working pressure of 75 lb., or if 100 lb. pressure was required, the limit to diameter was 11 feet 3 inches for single-ended boilers, and something less for double-ended ones. For a pressure of 150 lb. the diameter would have been only 7 feet 6 inches. Now, it need not be urged that this was prohibitive of higher pressures, although it had such an effect indirectly, inasmuch as the stays, etc., being of iron, too, would have been either of monstrous size or so close together as to render the construction impracticable. The weight of such boilers was also very much against them, and altogether it required more courage than then existed, and certainly less caution than then obtained, to attempt such strides as have been since successfully accomplished. I have stated that there was no theoretical difficulty with the insides of the boilers, but as a matter of fact there were some practical difficulties to encounter. Lowmoor iron was especially liable to blister from innumerable laminations when exposed to heat, and these blisters caused trouble enough with the pressures and temperatures then ruling. What the troubles might have been with the thicker plates, higher pressures, and higher temperatures were not known, and, like all unknown terrors, were feared most. There were also means well known for stiffening the furnace so as to withstand higher pressures; but these very means were also often sources of mischief, and always feared as likely to lead to accidents. It is true that we had the locomotive boiler working at pressures far beyond that of the ordinary marine boiler, but marine engineers were very chary of trusting to it, and events proved that their suspicions were not without foundation; for even now that the locomotive boiler has been used on shipboard to a considerable extent, its success on the sea has been decidedly qualified, and no one will use it unless circumstances compel him, and then only when he can get a supply of fresh water.

The supply of a material possessing all the good qualities of Lowmoor iron, without its bad ones, enabled Mr. Samson Fox, and subsequently others, to weld a cylindrical tube of almost any size, and so manipulate it by corrugating or raising ridges as to render it proof against the pressures we now require. Thus was the internal difficulty got over. That same material had an ultimate tensile strength fully 30 per cent. higher than that of the iron used in the boiler shell, and in addition was of such a nature as to permit of manipulations unknown with that material, and its price is no higher than that of Staffordshire iron. A boiler made wholly of this steel was cheaper, light-

* A paper read before the Iron and Steel Institute, New York meeting, October, 1890.

er, and better designed and manufactured than one of the older material when of the same dimensions and for the same pressure. Natural conservatism, or some other occult force, seems to have prevented the marine engineer from taking the full advantage of the splendid substitute you gentlemen were prepared to supply him with. I must not forget, however, that there was another force, which is one of the strongest we have in our professional work to combat, that was decidedly opposed to the new material; that was prejudice. I feel even now tempted to take up the cudgels against that old enemy of the engineer, but in this case it would be a waste of energy, as the dog is dead.

So far this was the condition of affairs when fresh demands began to be made on the marine engineer. The shipping world had had demonstrated to it that it was possible to cross the Atlantic at a higher speed than thirteen knots, and that the ships possessing this higher speed did their voyages regularly, and, according to rumor, were paying. Certainly both the American and the British public showed a preference for them, and there was a growing taste for speed at sea as there had been on land. The Inman and White Star companies had shown that fifteen knots was not only possible, but could be done with commercial success.

But it was urged that to get this speed the ships must be very large, costly in construction, and very expensive in maintenance. This was quite true, and it remained to be seen if they would pay when there were more of them, with the consequent competition. The Britannic was built of iron, had iron boilers, and was propelled by ordinary compound engines. She has been a very successful ship in every sense of the word, and holds her own to-day. But her speed is no more than fifteen knots still, and so she has to depend on something besides speed for a character now. She is a ship built prior to my period, and need be no further discussed. She is only taken as one of the causes which made a new demand.

That demand was for more speed. Now, with the same conditions, more speed meant with any ship more indicated horse power, more coal, larger boilers, and finally, to get the speed economically, finer lines. In other words, less ability to carry the heavier weights entailed by the greater power. The Arizona was the first supply to this new demand. Iron was the material used, the compound engine the moving machine.

The result was a gain of two knots per hour, equal to 13 per cent., with an increase in coal consumption of 50 per cent. The carrying capacity for the size of the ship was considerably less, the tonnage under deck being only 5 per cent. more. It will be seen that the cost of this excess of two knots was very great, first in the larger ship, then in the larger engines, then in the increased consumption of fuel, also that, owing to the extra weight of and space occupied by the machinery, together with the extra coal to be carried in the bunkers, the new ship was less able to earn sufficient freight to meet the expenses of the older ship, and still less able to meet her own. It is therefore evident that such a ship must depend almost entirely on passengers and light goods of high value, to enable her to be run profitably.

In spite of all these serious disadvantages, the demand for such ships continued, so that the Arizona was soon followed by the Oregon and Alaska, still larger and faster ships. These were followed by the Servia, City of Rome, and America. Then came the Aurania, Umbria and Etruria, and finally we have the City of New York, City of Paris, Teutonic, and Majestic of 10,000 tons, and doing twenty knots on the Atlantic per hour regularly. These were the supplies that marine engineers and shipbuilders gave to the demand for more speed. In fifteen years the speed has been increased from thirteen knots to twenty, and there is no reason to doubt that these ships pay very well in spite of their enormous cost and working expenses. Such ships are not only made to pay, but are actually only possible by what has been done by the members of this Institute. Without steel in both ship and machinery, such ships could not be built to accomplish the speed or to safely withstand the strain of sea and machinery.

The Britannic was built of iron, had iron boilers, and her engines were made more or less of iron in one form or the other. The City of New York is built of steel, has steel boilers, and her engines are to a very large extent built of steel. The saving in weight by the use of steel is very considerable in both ship and machinery, which admits of more cargo being carried, or of the lines of the ship being finer, so that a higher speed is possible with the same horse power, or the same speed with a less horse power and less consumption of coal.

Having thus briefly sketched out the origin and history of the demand for more speed in the Atlantic service, I will pass from this part of my subject with the observation that, if the owners or managers of ships in that trade had been well advised, they would long ago have separated the passenger from the goods trade. A steamer for passenger service only could have been built for the speeds now attained at far less cost in every sense of the word. It is only those who have to work out some of the problems set them by shipowners that appear to know and to appreciate the tremendous cost that is paid for the ability to carry the few hundreds of tons of cargo possessed by the "Atlantic greyhounds."

In 1875 there were many ships in the British navy capable of doing fifteen knots per hour on trial trips, but very few that could maintain that speed at sea. The necessity of having ships that could maintain that speed existed as soon as the mercantile ships of Great Britain could accomplish it. For not only would it be required that in time of war such ships should be convoyed, but the possibility of an enemy possessing such ships with which to harass the trade of the country was apparent. There was also the necessity for unarmored cruisers to possess a superior speed to battle ships for obvious reasons, and to act efficiently as sea police they must have a speed superior to that of any ordinary ship afloat. Hence the demand for better speed in her Majesty's navy.

The competition among the various steamship companies running in connection with railway routes, and others in competition with railway routes, caused a demand for an increase of speed for a different class of ships. In fact, in every direction there existed a demand for more speed, so that there was every incentive to the shipbuilder and engineer to exercise his keenest wit in devising new ways of accomplishing this desirable end.

It will now be my task to show how this has been accomplished by the marine engineer, so that the public can now travel at higher speed, with greater safety, with increased comfort, and at no higher cost, than obtained on the ocean fifteen years ago.

I have stated that one way of obtaining speed was by making ships with finer lines, and this had always to be done at a considerable sacrifice of carrying power.

Steel has, however, to a large extent obviated the necessity for such a sacrifice. New methods of construction and new forms of material have also tended to this end. Ironmasters now supply at reasonable rates bars of Z section, whereby the framework of the ship is much lighter, and at the same time stronger, than the old combination of angle bars. Then, too, this splendid steel that you now give us is capable of being so flanged, and that, too, when cold, that there no longer exists the necessity of riveting to the plate an angle bar, if it is sought to stiffen it, or to connect it to other work. You supply us now with such materials, at practically no extra cost, that we can construct our ships with much fewer plates, whereby we avoid the cost, weight, and disadvantage of so many joints.

You are no doubt told from time to time that this new material has a serious fault—that with all its good qualities, it is not so durable as the older one. This has a sufficient foundation of truth to make the opposition to it powerful. But with very ordinary precaution and care experience has shown that it can have the same endurance, and there is no doubt that with a better knowledge of how to treat it, this objection will entirely disappear, just as the same objection to iron ships existed, and has now been almost forgotten. The best remedy is to get rid of the mill scale before painting.

But while admitting that the naval architect has done much to bring about a successful solution of the speed problem, I must maintain that the marine engineer has done more. His path was not so obvious nor so clear before him, and new openings have often shown themselves in unexpected places.

Whether the marine engineer starts with a fixed weight given him by the naval architect, or whether the latter accepts such from the former, and designs the ship accordingly, is immaterial. The fact remains that the engineer, in order to get the maximum power, must get each individual horse power with the minimum of weight, in order that the ship may be a success, and his problem has been how to do this without adopting too costly processes.

His first step in this direction was comparatively obvious. An engine develops so much horse power at each revolution. If it can be made to do sixty per minute instead of fifty, the gain in power is 20 per cent.; and if the speed was at first 12 knots, it should now be 13·8 knots, or a gain of nearly a knot per hour. But how can we get this increase in the number of revolutions, and is it to be done economically? So far as the engines are concerned, it would mean an increase to the condenser only; and seeing that nearly all steamers at the date in question had too much cooling surface, it would probably have required no increase at all. But we must require more steam for this increase of power; certainly, and so the engineer of that day had to fit larger boilers to his ship. With large ocean steamers this was always possible, but for the smaller steamer it was not always possible, neither was it possible for the small steamer to carry the extra fuel. It is not necessary here to go into details, but it is a fact that the insuperable difficulty with this class in the endeavor to obtain more speed was the impossibility of obtaining sufficient space for the necessary boilers. Some other engineer would, however, attempt the increased number of revolutions by using steam of much higher pressure, trusting to its superior efficiency for the paucity of supply. If his engines were able to digest, so to speak, this superior article, and to make full use of its superior efficiency, he was undoubtedly on the right track. Hence the success of the Arizona and the ships that followed her was due to these simple departures. Later your steel admitted of still higher pressures being obtained from the boilers of succeeding ships, and the three-cylinder ordinary compound engines admitted of a higher rate of expansion without any practical drawbacks, as would have been the case with the four-cylinder compound engines of the Britannic. The possibility of constructing boilers for higher pressures by the introduction of Siemens-Martin steel, and that such boilers cost less money than the old iron ones, tempted some engineers to use steam at a pressure of 110 lb. in the ordinary two-cylinder compound engine, but with disappointing results. I am aware that this experiment of ten or twelve years ago has been again tried, and that its new fosterparents state that the system gives as good results as the triple expansion system. They deceive only themselves, and the evidence they give, so far as I have heard it, is conclusive of only one thing, and that is that the new boilers and better arrangement of cylinders that they have adopted now give better results than those they followed formerly. I was quite prepared to hear that the substitution of two cylinders for four, and the use of steam at 150 lb. pressure expanding ten times, would give better results than steam of 60 lb. expanded only six times; this is really what has been proved, and no more.

Having accomplished so much as I have stated, it remained for the engineer to follow the path on which he had found so much success, and we soon found him running even these large engines at eighty revolutions. Taking, as before, the increased power as proportional, viz., 60 per cent., the speed should now be 15·25 knots instead of 13. Revolutions have now done for him as much as he thinks prudent, so he has to start in a new direction, and this time it is in the nature of an enlargement of the engines. His brother engineer of the Naval Board has had to do this long ago, because he had started with a much higher number of revolutions—in fact, the mercantile engineer is taking up what the naval had left off. The naval engineer, however, is circumscribed in a way not unknown to the mercantile; he can only increase the size of the engine by an increase in the number of the cylinders, or in the diameter of them. He has tried the former since 1867, and until the compound engines forced themselves on him, Maudsley's three-cylinder engines had given him satisfaction, qualified, it is true, owing to a troublesome valve gearing. The mercantile engineer, filled with gratitude for what speed of piston had done for him, now sees his way to getting a still higher speed by lengthening the stroke, so that in 1886 he is getting close to the thousand feet per minute, with engines whose topmost part is visible from the deck without craning the neck through the skylight. Steam is supplied to the monster by numerous huge steel boilers, and the ship can carry little more than her fuel supply for the single voyage.

But before this climax has been reached, a veteran engineer has turned once more to an old idea of his own. His first experiment with it had, through no fault of it or him, failed. He finds that with this new good steel he can now build a boiler of a type well known and tried, and thereby get steam of the pressure he requires with certainty and safety; and in 1881, Dr. Kirk astonishes the shipping world by the success of the Aberdeen, having similar engines to the Propontis, made by him in 1874, but which failed. And why were the owners of ships so interested in the success of the Aberdeen, and what after all was her success? The steam pressure in her was very little higher than some others were then using, being only 125 lb., and at that time coal was as cheap as it had ever been; so that, although economy in its use was and always is of importance, it was not so much so as to cause a revolution so sudden and complete as that which followed. The fact is, here was the real solution of the speed question.

Since then, we have all learned that the triple engine burns less coal, can be run at a higher speed, and has less bulky boilers to supply it with steam than the old compounds, and that was what we were all wanting to obtain, higher speed in every class of ship, even in the so-called ocean tramps, which now glory in a ten-knot speed, whereas formerly the skipper was a proud man who could maintain a level eight knots throughout the voyage. The success, however, of the Aberdeen was something more even than this; here was a ship of moderate size, good speed, and good carrying capacity, that was going to do a very long voyage by a route where the coaling stations were far apart, and at some of them the coal very dear. Shipowners could now see before them fresh fields for enterprise, and the sailing shipowner learned before long that this same Dr. Kirk had created poachers on the realm so long held by him. The sailing ship has not been driven off the high seas, but steamers now run on tracks unknown to them till the triple engine existed.

The failure, in 1874, of the Propontis was, therefore, due to the want of a suitable material for boiler-making, which by 1881 you gentlemen had supplied to us, and permitted such a success to her designer that the trade of the world has been thereby revolutionized. The saving of fuel has been stated, challenged, debated, and discussed *ad nauseam*. The fact remains that it is substantial, and is approximately 20 per cent. where all other conditions are the same. Experience has proved that the three-crank engine is capable of being run at higher speeds than the two-crank one, and that its wear and tear is absolutely less. The boilers being required to supply 20 per cent. less steam, can, of course, be 20 per cent. less; or the same size of boiler will supply steam for 20 per cent. more power. This latter fact was the one made more use of by the generality of shipowners, partly by design, but oftener by unbelief. Hence the superior speed of many of the "tramps" is due to the latter; that of small passenger steamers, almost wholly to the former.

On the whole, the saving of coal by means of the triple compound engine has been rather in the direction of the allowance per horse power than per ton carried, as the ton carried is almost universally carried now at a higher speed. The actual saving is nevertheless a very substantial one, both to the world and to the individual shipowner, for a ship, if run at a higher speed, makes more voyages in a year, so that the trade is done with less capital, which means less tonnage. The demand for less tonnage no doubt depresses the freight rates, and so the unfortunate shipowner does not reap the harvest, but only as it is shared by the public at large. The continued depression in shipping is undoubtedly due to Dr. Kirk's genius, and hence he gets so little praise.

(To be continued.)

CONSOLIDATION OF FOUNDATIONS IN PARIS.

The catacombs, which constitute one of the most visited parts of Paris, are merely vestiges of the ancient situation of its subsoil.

The ancient quarries, in fact, reach over nearly a third of its present total area, as shown in the plan (Fig. 1) from Mr. Dunkel's work * These exploitations, which have furnished capital, since its origin, with the building material that it has needed, such as stone, plaster, plastic clay for bricks, sand for mortar, etc., have successively retired before the continuous extension of the population, thus ever becoming more distant from the center of the city. Moreover, the annexation, in 1861, of the communes of Montmartre, La Villette, and Belleville, which contained numerous gypsum and limestone quarries, further increased the proportion of the excavated subsoil. But, for a number of centuries, the subterranean or open air exploitations have been abandoned to themselves, without surveillance or regulation.

Begun, or given up arbitrarily, falling in through the effect of natural causes, or remaining more or less solid in parts, the galleries have for the most part become inaccessible, and there has been no exact information as to but a very small number of them. However, previous to 1774, it appears that there was no cause for inquietude as to the grave inconveniences that these subterranean excavations present as regards the stability of buildings and the safety of the streets. But during the course of that year an extensive caving in of the earth occurred near the barrier D'Enfer and attracted the notice of the government.

A general visit and a drawing up of plans of all the excavations having been ordered in 1776, the certainty was acquired, as tradition had asserted, that the

* *Topographie et Consolidation des Carrieres sous Paris.*

temples, the palaces, and the majority of the public roads of the southern quarters of Paris were on the point of tumbling into deep abysses; that the peril was so much the more to be dreaded in that it was imminent at every point; and finally that it was necessary to proceed to each of them. But, unfortunately, there were as yet no data as to the proper course to pursue in order to remedy the most alarming trouble or even to arrest the progress of it. The ascertaining of these facts caused the creation of a "General Inspection" of the quarries, which still exists.

Its service consists in making the researches and doing the work necessary to consolidate the earth undermined beneath the streets and public buildings of Paris.

The work of consolidation consists in the filling in of

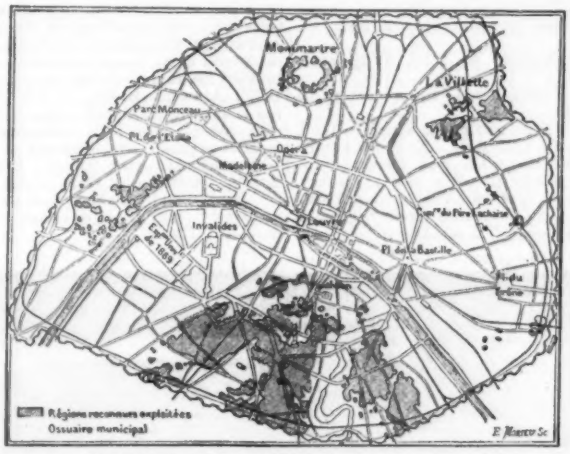


FIG. 1.—PLAN OF THE UNDERMINED PORTIONS OF PARIS.

the caved-in portions and of the mischievous voids, and in the building of pillars, walls or vaults.

Now, owing to the perseverance with which these operations have been carried on for more than a century, the earth consolidated in the streets is no longer liable to subsidence, and the structures, sewers, gas and water mains, etc., are secured against the serious accidents that might result from it.

The same is not the case with the ground upon which private buildings stand. It is, in fact, very difficult to get access to the galleries beneath these without special labors, unless they have been met with in the municipal operations and have remained in communication with the galleries preserved. So, in most cases, any application of preventive measures is impossible, and it is possible to employ more or less adequate measures only after a subsidence has begun to take place, as happened, especially in 1879, in the Gourdon passage at Montrouge, where three houses came near being engulfed, and in April, 1880, in the Boulevard Saint Michel, and more recently at Montmartre.

Those accidents determined the prefectural authority, in 1881, to compel builders to consolidate the subsoil under the surveillance of the inspection when new structures are about to be erected. But it sometimes happens that work of this kind has to be undertaken for old buildings. The example of the consolidation of the substructures of the Lahure printing establish-

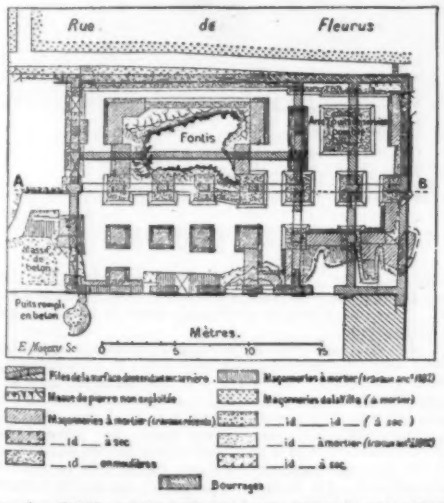


FIG. 2.—CONSOLIDATION OF THE QUARRIES UNDER THE LAHURE PRINTING ESTABLISHMENT.

ment, effected by Architect Perronne, will give our readers an idea of the difficulties met with in this sort of operation.

The offices were arranged upon the perimeter of a central court, which it was resolved in 1882 to utilize for their extension. Borings showed that this court rested upon galleries whose filling had gradually settled, leaving above it vaults that were almost everywhere fissured.

As the first trial of foundation work in shafts did not seem as if it would secure adequate solidity, Mr. Perronne decided to establish under the subsoil immense cellars whose foundations should rest upon the bottom of the quarries.

This work necessitated a digging to a depth of 35 feet over the larger part of the surface of the court and the shoring up of the adjacent structures, and required for shoring up the structure, Mr. Perronne decided to strengthen the masonry piers with cast iron supports.

But upon what were the latter to be established? Another examination of the earth had to be made, and in order to avoid stopping the work of the printing offices, it became necessary to open subterranean galleries directed toward the piers to be consolidated—an operation that presented so much the more difficulty in that the upper masses of iron exerted their influence upon the compass, and which could be performed only by detached stations.

Moreover, the roof of the quarry was found almost everywhere to be in the state of subsidence that the work of 1882 had shown the subsoil of the court to be in. (Fig. 2.)

Further, a large caved-in space was encountered, and it was found that the base of the piers to be consolidated reached firm ground, but were beginning to crush. The replacing of their courses, except at the risk of causing a subsidence, could not therefore be thought of, and so they were surrounded with masonry work of millstone grit and cement, which could serve, too, as a support for the cast iron columns. At the same time, in order to finish the consolidation of the roof of the quarry, other piers of millstone grit were constructed upon the perimeter of the caved-in portion and upon some other points. (Fig. 3.)

The thinness of the covering rendered these opera-

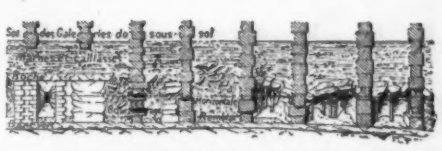


FIG. 3.—SECTION TAKEN DURING THE EXPLORATION OF THE QUARRY, AND PASSING THROUGH A B OF THE PLAN.

tions very perilous, for the least falling in in the quarry would have carried along the mass above.

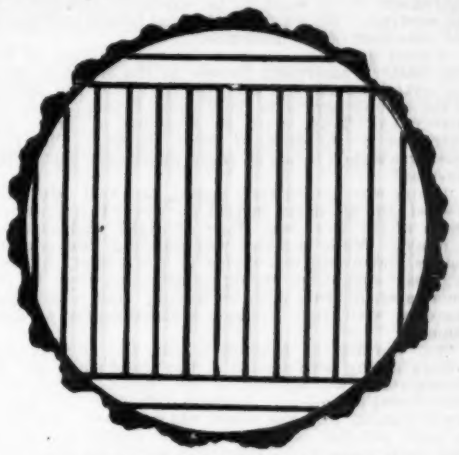
The work was nevertheless executed without accident and without any necessity of stopping the operation of the presses, the weight and jarring of which had caused the subsidences mentioned above.

FIG. 4.—SECTION TAKEN AFTER THE COMPLETION OF THE WORK.

At present the foundations of the Lahure printing establishment seem as if they ought to afford entire security, and this house can, besides, utilize double cellars for store rooms.—*La Nature.*

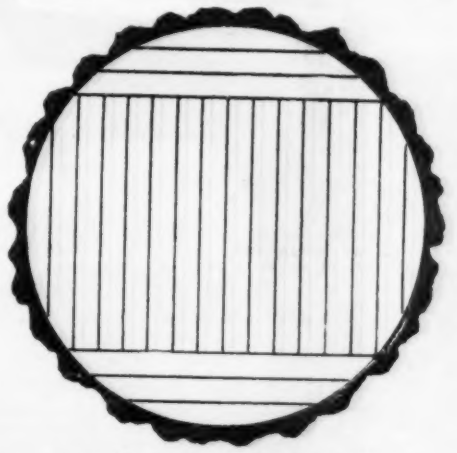
CIRCULAR OR BAND, WHICH?

A CANADIAN machinery firm has undertaken to demonstrate the difference in the profit of cutting lumber with a circular or a band mill, and to do so they have made the following diagrams as showing the products of logs sawed by a circular mill with a large kerf, and another log of the same size sawed with the thin saw of a band mill, and in connection with the same makes estimate of cost of material, wear and tear, etc., and places the profits on 3,000,000 ft. of pine at $9 per thousand cut by a circular mill as $5,400; on the same basis, but cut by the band mill process, he makes the profits on 3,000,000 ft. at $9 per thousand, $11,820. We herewith reproduce the statistical statement out of which these profits are figured, as well as showing the product from the two logs under the circumstances above mentioned:



SEASON'S STUMPAGE THREE MILLIONS.

	Cost.	
Stumpage and dues	$2 50	
Cutting, watering, and delivering at mill	3 50	
Cutting and piling	2 00	
Loading on cars	25	
Int. on 18,000 ft. one year, 7 per cent., $12.80	40	
Wear and tear of machinery	35	
Three millions at	$9 00	$27,000
2,700,000 at $11	$29,700 00	
450,000 culls at $6	2,700 00	32,400
Profit		$5,400



SEASON'S STUMPAGE THREE MILLIONS.

	Cost.		
Stumpage and dues	$2 50		
Cutting, watering, and delivering at mill	3 50		
Cutting and piling	2 00		
Loading on cars	25		
Interest and expenses	75		
Three millions at	$9 00	$27,000	
3,240,000 at $11	$35,640 00		
540,000 at $6	3,240 00	38,880	
		$11,880	
Int. on extra cost of mill, $1,000		60	
Profit		$11,820	

—*The Timberman.*

THE FIRST MONITOR.

THOMAS F. ROWLAND, a well known engineer and shipbuilder of this city, writes to the New York *Times* as follows:

"In October, 1861, I received a note from Capt. John Ericsson requesting me to call on him. I went to the captain's house as requested. He asked me if I had seen the morning papers. I said: 'Yes. I know you have a contract awarded you by the Secretary of the Navy.'

"'Yes, sir,' he said. 'Now, Tom, what will you charge me per pound to build my iron-clad battery, I furnishing you with all the necessary material?'

"I said: 'I will answer that question at 10 o'clock to-morrow morning.'

"I was there on time the next day, and stated the price, 7½ cents per pound on all the iron material used.

"Contracts for the woodwork, armor plating, armor backing, etc., were subsequently made at stated sums.

"Capt. Ericsson said: 'Your price is enormous. I know very well it is half a cent per pound too much.'

"'Yes, captain,' said I, 'but you know I am to make extraordinary exertions, working night and day and Sundays if you so order. I therefore think the price named is equitable.'

"He at once agreed with me, and ordered me to write the contract and insert that price. I am particular that this shall be mentioned, because of the fact that stories have been going the rounds that

Capt. Ericsson tried to beat me down on my price for building that vessel. I subsequently built four other ironclad monitors under contract with Capt. Ericsson, and in no one instance did he ever pay me or ask me to accept less than the sum which I named as a fair equivalent of the work to be executed according to the contract. He was, in fact, most liberal and fair in his treatment of the mechanic.

"I soon drew the contract for the building of the iron battery, afterward known as the Monitor, making myself the party of the first part, and the parties of the second part were Capt. John Ericsson, John A. Griswold, of Troy, John F. Winslow, of Troy, and Cornelius S. Bushnell, of New Haven. The contract was signed by all of these gentlemen except Mr. Bushnell.

"Work was immediately begun, the keel laid, sides erected, and all parts carried on toward completion. Much of the work was done at night and some on Sundays. While the hull was building, the engines, boilers, revolving machinery of the turret, blowing engines, etc., were being constructed by C. H. Delamater, of this city, he having had a contract therefor, with Capt. Ericsson and associates as mentioned.

"On the 31st of December, 1861, the engines and boilers having been erected in the vessel while on the stocks, steam was applied to the engines, which were fully tested in motion. At eight o'clock in the morning of Jan. 30, 1862, the vessel was launched. She was of such peculiar construction that many prophecies had been made as to what she would do when put into the water. It was the opinion of most ship builders that she would 'throw pitch pole'—that is to say, her stern would go immediately down into the mud at the bottom of the river and she would turn a somersault.

"But her peculiarities I had provided for by putting air tanks under her stern, and by an automatic device allowing the air to escape and the water to run into those tanks just in proportion as the vessel should be immersed in the water while leaving the ways. She was enabled thereby to slide into the water as quietly as a duck going into a pond to swim. Her decks were scarcely wet. Capt. Ericsson stood at the extreme stern, and would certainly have been drowned had the fears of those ancient ship builders proved correct.

"One of these, an old man who had built many clipper ships, came over to the yard to see her a few days before the launching, and after studying her fore and aft said to me:

"'Young man, I am very sorry for you!'

"'Why?' I asked.

"'Because your boat will 'turn turtle' and go to the bottom of the river.'

"'I wish I had a million,' I answered, 'to bet you that she won't.'

"It was her comparatively shallow hull and long, overhanging deck—much longer at the stern than at bow, as you can see by the model—which excited the fears of the ship builders of that day, and but for the air tanks she would undoubtedly have realized their fears. But I had made my calculations, and was perfectly certain that the device would operate according to my expectations. Besides the automatic contrivance for allowing the air to escape, there was a string for opening the valve wider if necessary, and a man stood ready to pull it, but there was no necessity to touch it. The device operated exactly as I had calculated, and Captain Ericsson told me afterward it was as perfect a bit of scientific provision as he had ever seen.

"The vessel was immediately brought to the dock and the work of completing the erection of her turret and other parts continued without delay. One of the features of the design of this vessel of which Captain Ericsson was exceedingly proud was the bare appearance thereof when ready for action. Nothing save the turret with pilot house and flagstaff was to appear upon the decks. The stanchions, smokepipes, and all other movable appliances, were to be stowed below before going into action. The day was set for her trial trip. This, though not in my contract, Captain Ericsson ordered me to superintend. I had the smokepipes set up and everything in readiness to cast off lines and proceed down the bay at one o'clock of a certain day, at which time Captain Ericsson agreed to be on hand. As he stepped from the pier to the boat, he said to me:

"'What are those smokepipes up for? Why don't you take them down, sir!'

"I replied: 'We must have them up in order to carry fifty pounds of steam.'

"'Take them down, sir!' he returned, which order I immediately directed to be executed. The lines were cast off, and we proceeded down the East River at the rate of about six knots per hour. We had got below Governor's Island, when it was reported to me from the engine room that we had less than twenty pounds of steam and could get no more. I addressed Captain Ericsson and asked him who was responsible for the safety of the Monitor on that particular occasion. He replied:

"'You are, sir!'

"'Very well,' I said, 'then up go the smokepipes!' But unfortunately he had directed that they be left on the pier at the Continental Iron Works. I had taken the precaution to have a tug within hailing distance of us on the trip. Lieut. Commander, now Admiral Worden, being with us and not very well, I hailed the tug, ordered the captain to set him ashore at Whitehall Street, and then proceed with all possible dispatch to the Continental Iron Works, get the smokepipes, and bring them to us. Before the tug returned to us we were well down the Narrows, and it was dusk when we got the smokepipes in position and began to gain steam. We turned her head toward the navy yard, but for some unaccountable reason the old pilot, John McGinn, pointed her through the Buttermilk Channel, where we stuck hard and fast on the shoal bottom. However, the tide being flood, we did not have to lie there long. We steamed to the navy yard and dropped anchor about midnight near the Cob Dock, when my connection with the vessel ceased.

"She was taken hold of by the navy yard authorities, fitted with stores, ammunition, etc., and made ready for sea. When she left the navy yard she was to proceed to Washington, there to be inspected by a board of naval officers appointed for that purpose; and fortunate it was she was delayed by the way to fight the Merrimac, for if she had arrived at her destination, I doubt not she would have been condemned because of inferior workmanship, coarse material, etc., incident to the fact that she had been built in so short a period of time.

"At the time the work was commenced, Capt. Ericsson said to me, 'Tom, you can make all the profit out of this job, I want all the glory.' I replied, 'That is the kind of man I like to work for.' After I had drawn the contract and he had approved it, I said to him: 'Captain, you haven't got any more money than I have. Where is the money to come from for this job?'

"'I will furnish you all the iron you need, sir,' he replied.

"'Yes, but the iron is not all,' I ventured; 'the men will have to be paid their wages.'

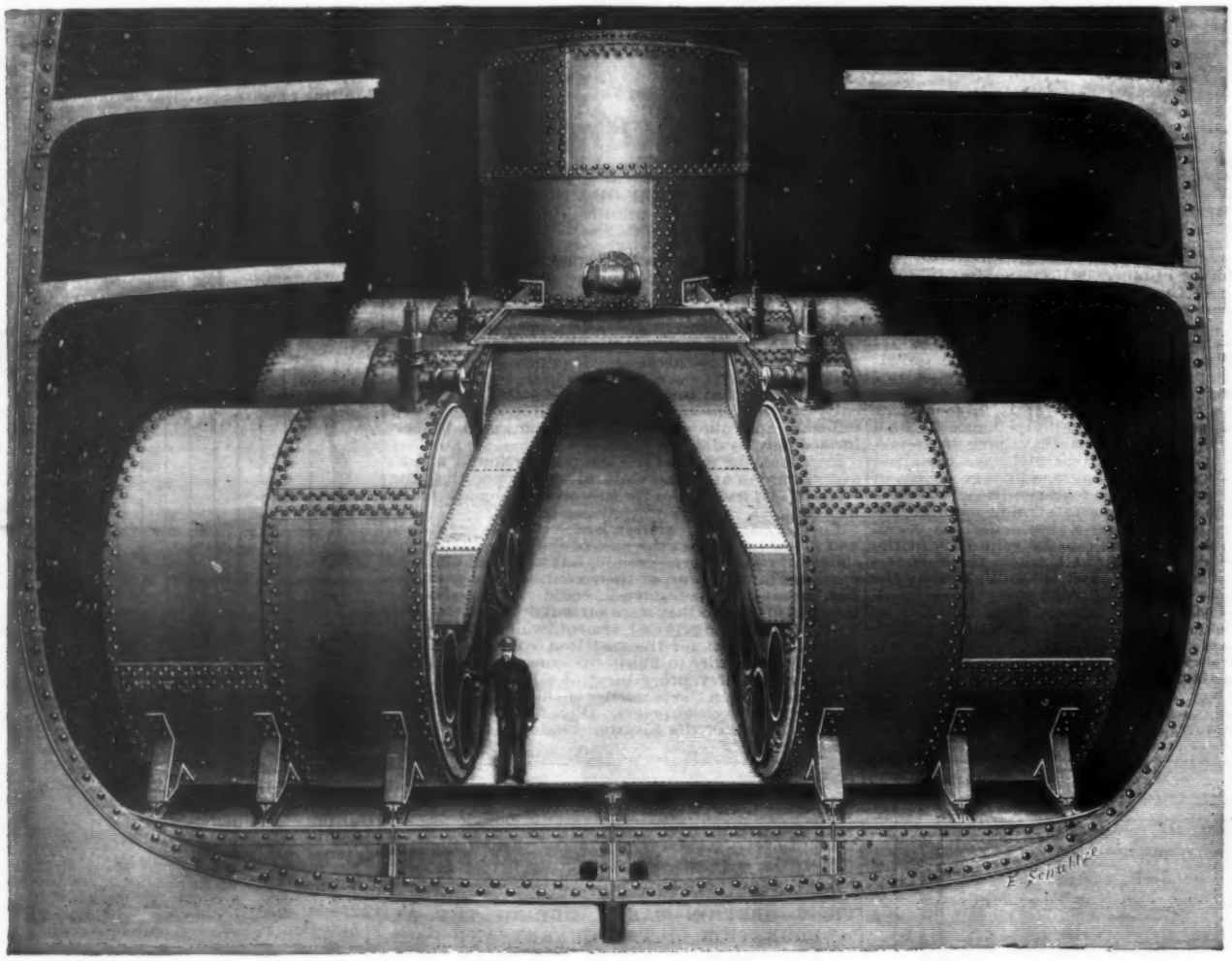
"'Well,' said he, 'you go to Troy and ask John A. Griswold if he will furnish you all the money I tell you to ask for.'

"I did not know who John A. Griswold was, and I thought it would be rather a foolish thing to do to go all the way to Troy to ask him such a question, but I did not tell Capt. Ericsson so. I went to an acquaintance in the iron business and ascertained that John A. Griswold was president of the Rensselaer Iron Works and also of the Troy City Bank. I asked my friend if he would give me a letter of introduction to him, but he said he could do better. Mr. Griswold was at the Fifth Avenue Hotel, in this city, and he would give me a personal introduction that very afternoon. It was about 5 o'clock when we went there, and Mr. Griswold had just dressed for dinner. I said: 'Mr. Griswold, will you furnish me all the money Capt. Ericsson tells me to ask you for?'

"He flushed up somewhat and said: 'Who are you, anyway? Oh, are you that Greenpoint man? Yes; certainly I will."

"Mr. Winslow, who is still alive, was also at that time in the iron business at Troy. Mr. Griswold is dead. His son, Chester Griswold, lives in this city and is well known.

"Capt. Ericsson was a very stern, positive man, but he was easy enough to get along with if you did what he told you to do. I always did, and so never had any trouble with him. While the Monitor was on the stocks he was at my yard every day, and generally all day long, without even going away for lunch. He used to come over in a cab, and while he would always give the cabman money to go and get lunch, he seldom went himself. He said he was going to build a house around the Monitor so that she could not be seen, and he did build it, but the vessel was half done before he finished it."



BOILERS OF THE P. M. S.S. CO.'S STEAMER CITY OF SYDNEY—BUILT BY THE RISDON IRON WORKS, SAN FRANCISCO.

NEW BOILERS OF THE PACIFIC MAIL STEAMSHIP CO.'S STEAMER CITY OF SYDNEY.

THE boilers are six in number, placed three on each side of the vessel, and fired athwart ship. With the exception of tubes and braces, they are constructed throughout of mild steel. Each boiler is thirteen feet mean diameter and ten feet six inches long, and is fitted with three corrugated furnaces, 36½ inches minimum external diameter, seven feet six inches long, having separate fire box to each furnace. The number of tubes in each boiler is 204, and are 3¼ diameter; 32 of these are fitted as stay tubes. The furnace fronts are flanged outward to receive the furnaces, this system affording the ability of hydraulic riveting. The back head is also flanged outward for attachment to shell plates for the same reason. All the rivet holes

throughout have been drilled in place. The circular and longitudinal seams are double riveted, the latter fitted with butt straps inside and out, all of which are riveted up with hydraulic pressure. The collective heating surface of the six boilers amounts to 9,612 square feet, and a total grate area of 324 square feet. Horse power, 3,240.

Considerable attention has been given in designing the boilers to provide ample means for cleaning and the thorough internal examination, a point which is too often overlooked. They have been constructed to conform with United States laws for a working pressure of 80 pounds, and have been tested by hydrostatic pressure to 120 pounds and found to be perfectly stanch and water tight. Each boiler is fitted with a main stop, spring-loaded safety, separate main and donkey feed, scum and blow-off valves. The main feed is delivered into the boilers through Matthews' patent feed heating apparatus, a system which has proved highly successful, not only in prolonging the life of the boiler, but also in the economy of fuel. The steam generated in the boilers passes into a superheater twelve feet diameter and fifteen feet long, having an internal flue 7 ft. 4 in. diameter. The superheater is also fitted with stop and safety valves, so that connection from all the boilers with main engines may be severed by the closing of one stop valve. The work throughout has been conducted under the supervision of Mr. J. Matthews, the Pacific Mail Co.'s marine superintendent. The Risdon Iron Works, San Francisco, builders.—*Pacific Lumberman.*

THE NEW DOCKS AT SOUTHAMPTON.

THE Southampton docks are situated in a very safe position within the land-locked port, and are accessible at all states of the tides and in all weathers. They are owned by the Southampton Dock Company, were commenced in 1838, and opened for business in 1844. The estate of the company covers 208 acres. There is a complete system of railways throughout the dock property, ten miles in length, extending to all the quays, and into and alongside each warehouse—and connected with the main line of the Southwestern Railway—so that trucks pass direct between the docks and every railway system of the kingdom.

On the 26th of July, 1890, the new floating basin or open dock, which has been in construction for some years, was opened, and the Queen honored the ceremony by her presence.

The engraving gives an excellent idea of the general arrangement of the Southampton docks. We are indebted to the *Engineer* for our illustration and the following particulars:

The new deep water dock, containing an area of 18 acres, is that shown farthest from the town. It is of an irregular diamond shape, the northeast and northwest wharves being each 850 feet long. The southwest wharf is also 850 feet. The southeast wharf is 50 feet shorter. The entrance, almost due south-southeast, is 175 feet wide, the entrance walls at each side being 200 feet long. At low water of spring tides there is 26 feet of water all over the dock, so that the largest vessels can be accommodated. Mr. Alfred Giles, M. Inst. C.E., M. P., is the engineer; Messrs. S. Pearson & Son were the contractors. Cement concrete has been largely used in its construction. The cargo sheds on the western side are almost complete. The others will be constructed as the need for them arises.

The docks previously existing at Southampton, and also shown in our engraving, consist of a close dock, rectangular, nearly square, containing an area of ten acres, and with a water depth of 28 feet. Between it and river Itchen is an open dock of 16 acres, with an average depth of 18 feet at low water springs, the average rise of the tide being 13 feet. Opening out of it to the south are three parallel dry docks. That lying to the west is 500 feet long on the blocks, and 31 feet deep; the entrance is 66 feet wide. Next comes a small dock 251 feet on the blocks, with an entrance of 51 feet. The third dock has 80 feet gates, is 500 feet long on the blocks, and is 23 feet deep. Parallel to the Itchen lies a fourth dry dock, which can be entered from the south direct from the river. This has 56 feet gates, and is 450 feet long. The dock company still possesses a large area of land, which can be utilized when necessary for the construction of an open basin.

It is a curious fact that there are double tides at this port. In addition to the usual high water, there is a second high water about two hours after the first. This peculiarity—found in no other port—is accounted for thus: The Isle of Wight being situated across the entrance to Southampton Water, a portion of the great tidal wave, in its progress up the Channel, becomes separated from the main body, and flowing up the Needles passage into the Solent, reaches Southampton, and causes the first tide about the same time that the main body arrives at Dunnose Point. This tide beginning to ebb, is stopped and driven back again by the main stream from Spithead, and hence the second tide, about two hours later, and six inches higher than the first tide. Low water is about three and a half hours after the second flood tide. To ships using the port this is obviously of great advantage, the water remaining nearly stationary for two hours, allowing vessels to come out of the graving docks without risk, and others to enter without losing a tide.

The fullest facilities exist for coaling steamers, both from rail or collier. Railway wagons run from South Wales and other collieries direct to ship's side. The railway distance from Aberdare, *via* the Severn Tunnel, is 129 miles.

The most complete and approved accommodation and appliances are provided for carrying on the foreign animals trade, under the Privy Council orders, with every facility for landing at all states of the tide, lairage, feeding, cleansing, inspection, slaughter, sale, and dispatch of cattle by railway direct to the metropolitan markets and other places. The Lords of her Majesty's Privy Council have defined a foreign animals wharf at the docks, where animals can be slaughtered. This wharf is isolated within a strong close fence. Lines of railway run on to the wharf, and to the abattoirs and cooling houses. The Lords of the Privy Council have also defined a foreign animals quarantine station. Animals landed there must be intended for the purposes of exhibition, or for other exceptional purposes. The Lords of the Council have further defined at the Southampton Docks a foreign animals reshipment station; animals landed thereat must be intended for reshipment to a foreign country. Southampton is the only port which provides for the quarantine of foreign animals.

The approaches to the harbor, and the harbor itself, are very well buoyed upon the uniform system, and lighted by the commissioners, who are now carrying out important dredging operations for the improvement of the harbor. There is a time signal on the South Castle, the situation of which is latitude 50° 53' 39" N.; longitude 1° 24' 5" W. The signal is a ball dropped by electricity from Greenwich, and is made once daily, with the exception of Sundays and holidays. The ball is hoisted about five minutes before the signal, and dropped at 1 h. Greenwich mean time.

THE NEW SOUTHAMPTON DOCKS.

AMERICA THE GREAT CONSUMER.

THIS country has but about one-twentieth of the world's population, but it consumes 28 per cent. of the world's crop of sugar, 30 per cent. of the world's production of coffee, nearly one-third of the world's production of iron, about a third of the world's steel and copper, more than a quarter of the world's cotton and wool, a third of the India rubber of the world, and more than half of the world's supply of tin, and 40 per cent. of all the coal from the world's mines.—*Boston Journal.*

MEETING OF THE IRON AND STEEL MEN AT PITTSBURG.

IT was a distinguished assemblage that gathered in Carnegie Hall on the morning of October 10, for the first joint session of the British, German, and American societies of engineers and men learned in metallurgy.

It was the first time that the representative societies of men—deep thinkers and practical exponents of the results to be obtained from the fusion of metals—of the world met in common to discuss the progress of science in their particular pursuit. And that Pittsburg should have had the honor of being selected for this distinction is a matter of which her citizens should feel duly proud.

The hall was well filled by the distinguished visitors and many ladies graced the meeting by their presence when Sir James Kitson called the meeting to order. On the platform with him were Sir Lowthian Bell, Sir John Alleyne, Sir W. T. Lewis, E. Windsor Richard, G. J. Snelus, John H. Ricketson, E. V. Martin, William Whitwell, and Mr. Jeans.

Sir James Kitson briefly stated the purport of the meeting, and then John H. Ricketson, chairman of the reception committee, made the address of welcome.

Mr. Ricketson regretted the absence of Sir Henry Bessemer, and wished he had been successful in his efforts to build a steamship to which sea sickness would be a stranger. He welcomed Dr. Wedding, Mr. Daelen, Mr. Thieler, and Mr. Schroeter, and regretted the absence of Abram S Hewitt. He mentioned George Westinghouse as one of the great inventors of the age, and regretted the absence of a former fellow citizen to whose generosity the city was indebted for the magnificent building in which the meeting was assembled. Proceeding, Mr. Ricketson said:

The other day, in New York, one of our foreign guests (I will not say whether he came from the mother country or the "Faderland") asked me the name of the lake on the borders of which Pittsburg was built. The mistake was a very natural one—we Americans often find ourselves equally uncertain in our geography when we are abroad; no, perhaps a word as to where we are may not be out of place. We are at the foot of the western slope of the Alleghenies, within the watershed of the Mississippi Valley, about 750 feet above the level of the sea, 444 miles west of New York, about 150 miles from the nearest port on Lake Erie, whither our ore comes by water from Lake Superior and thence reaches us by rail. The greater portion of Pittsburg lies between the Allegheny and Monongahela rivers, the former rising in New York State, and the latter in Virginia. Together they form the Ohio, whose waters wash the shores of ten States as it winds its way for more than 2,000 miles to the Gulf of Mexico. A steamer starting from and returning to Pittsburg can sail over 2,000 miles of navigable rivers, all tributaries of the Ohio and the Mississippi, and reach on the upper Missouri a distance from this point of 4,300 miles.

Pittsburg was laid out in 1765 on the site of the old French Fort Duquesne, so famous in colonial history, and on its capture by the British the name was changed to Fort Pitt, in honor of your great statesman William Pitt, from whom our city derives its name. Time will only permit me to add that almost within the city limits the unfortunate General Braddock laid down his life in defense of the British flag, and with him the young American civil engineer from Virginia, George Washington, received his baptism of fire and won his spurs.

Our committee have prepared for you a little souvenir of Allegheny County, and incorporated with it are some general statistics of our leading industries and many facts of historical interest to iron and steel men. I will content myself with a very few totals, in order to give you at the outset some idea of the extent and variety of our resources.

We have 21 blast furnaces, which in 1890 produced

1,203,435 tons of pig iron; 33 rolling mills, 27 of which roll steel, and their production in 1889 was 1,105,573 net tons of steel and 638,450 tons of rolled iron. Our annual capacity of steel rails is at present 550,000 tons. Our product of wrought iron pipe this year will, I am informed, not fall short of 350,000 tons, while our output of structural iron and steel will be fully 165,000.

We have 49 iron foundries, representing a capital of nearly $10,000,000.

The principal electrical industry in Pittsburg is in apparatus for incandescent lighting. Of the dynamos in the United States having a capacity for the supply of current for 1,500,000 16-candle powder lamps, Pittsburg alone has furnished 650,000 of this, or nearly 44 per cent. We have fifteen firms or companies making window glass, 37 making flint and lime glass, and 15 making green and black glass bottles.

The 15,000 coke ovens in this district consume 9,000,000 tons of coal in making their product of about 6,000,000 tons of coke. In 1889, in round numbers:

We shipped to Southern markets by river	4,000,000
We shipped to Eastern markets by rail	2,500,000
We shipped by rail for reshipment by lake	1,000,000
Railroads entering Pittsburg used	1,000,000
We shipped by rail to Northeastern markets	500,000
We used for home and miscellaneous trade	2,000,000

Making a grand total of 20,000,000 of tons, or sixty per cent. of the output of bituminous coal in Pennsylvania.

The railway tonnage of Allegheny County, of business originating here, exclusive of what passes through, is 20,000,000 tons per annum, or a fraction over 3 per cent. of the total railway tonnage of the United States, which amounted in 1889 to 619,137,237 tons.

One word as to natural gas, that wonderful fuel which has been distilled for us in nature's own alembic. I am officially informed that in this district 750,000,000 ft. of gas are delivered to consumers each day through 1,125 miles of pipe to our mills and factories, and to upward of 30,000 private warehouses, stores, hotels and dwellings. The present annual displacement of coal by natural gas is estimated at about 8,000,000 of tons.

There are 46,000 oil wells in the United States, producing on an average 130,000 barrels per diem, and representing a capital of $120,000,000.

The district including Western Pennsylvania, West Virginia and Southeastern Ohio produces 85,000 per day, and Allegheny County 10 per cent. of the latter amount.

There are 10,000 miles of pipe lines for the transportation of crude petroleum, involving a capital of $50,000,000.

The stock in tanks at present of crude petroleum is 26,500,000 barrels. The country has a refining capacity of 140,000 barrels a day for illuminating oil; 15,000 barrels a day are used for fuel purposes.

PETROLEUM PRODUCTION.

Gentlemen, when, in addition to the 300,000,000 of barrels of petroleum which have flown from the soil of Pennsylvania from 1876 to 1890, we remember that she is still producing 2,500,000 barrels per month, that her total yearly output of bituminous coal is 30,000,000 of tons and of anthracite 35,400,000 of tons, and that she produced last year within a small fraction one-half of all the pig iron and more than half of all the rolled iron and steel made in the country, you can form some conception of the immeasurable and boundless, though then hidden, resources of the princely domain of 44,985 square miles which King Charles II ceded to the Penns in satisfaction of a claim against the British government for £16,000.

Mr. President: Naturally, from the character of our industries and avocations, no section of the country appreciates more fully than ours the significance, importance and far-reaching consequences of your visit to America. We, probably, more than most of our countrymen are familiar with the history, the objects and the achievements of the Iron and Steel Institute, the highest metallurgical authority in the world. Numbered among your members are not only scientific men of universal reputation and capitalists and captains of the world's industry, "Knights of Labor" in the true sense of the word, but on your roll are many who from a distinguished ancestry are by inheritance the possessors and guardians of some of the most honored names in English history. In the journals of your proceedings has been chronicled every step in the onward march of the great material forces of modern civilization for nearly a quarter of a century. Organized in 1869, your Institute this year attains its majority, and we esteem it a privilege and an honor to unite with you in celebrating the event on American soil.

When the manufacturers of the civilized world unite in taking counsel with each other, and freely sharing their experiences in the search for the hidden treasures of nature and the secrets of her laboratory and workshop, lasting and ever-increasing benefit cannot fail to accrue to the welfare, comfort and happiness of mankind.

Mr. President: More than 2,000 years ago a Hebrew sage, in the spirit of prophecy, the fulfillment of which we are witnessing to-day, uttered these words, which in this presence seem like a benediction:

"Every carpenter and work master that laboreth night and day * * * * * the smith also sitting by the anvil and considering the iron work, the vapor of the fire wasteth his flesh, and he fighteth with the heat of the furnace; the noise of the hammer and the anvil is ever in his ears, and his eyes look still upon the pattern of the thing that he maketh."

"He setteth his mind to finish his work and watcheth to polish it perfectly."

"So doth the potter sitting at his work and turning the wheel * * * * * * * * * *

"All these trust to their hands and every one is wise in his work. * * * * * * * * *

"Without these cannot a city be inhabited. They shall not sit on the judge's seat, nor understand the sentence of judgment, and they shall not be found where parables are spoken."

"But they will maintain the state of the world and all their desire is in the work of their craft." [Prolonged applause.]

INTERESTING ADDRESS BY SIR JAMES KITSON.

Sir James Kitson replied in behalf of the visitors. He mentioned the surprise with which he and his fellow members had approached the city, with its blazing mills, its outburst of natural gas, and the general aspect of great industrial wealth. He then continued:

By the courtesy of the president and council of the Institute of Mining Engineers of the United States, I have been invited to take the chair, and to open the proceedings of this Congress. It is a graceful compliment to those members of the Iron and Steel Institute who are your honored guests at this moment—an acknowledgment of high consideration for scientific services rendered to a great industry by the Iron and Steel Institute, and a marked distinction conferred upon the president of that Institute. I gratefully accept the position, and I now undertake the duty because, although I am fully conscious of my own deficiencies, yet I feel that the Institute is worthy of the respect you show to it; and, also, I know that we have the happiness to count among our members men who merit the honors you offer, whose names are known throughout the world as metallurgists and leaders in scientific study of the laws which govern the acquisition and production of those metals which we know as iron and steel.

Our Institute is not exclusively British; in truth, it is cosmopolitan, having enrolled on its list of members distinguished metallurgists of the United States, Germany, France, Sweden and Russia. The birthplace and the headquarters of the Institute are in England. It will, therefore, I hope, not be considered in any way presumptuous if I ask you for one moment to consider how much the world is indebted to my native land for the vast benefits which mankind has received from its engineers and its manufacturers of iron and steel.

SOME OF THE WORK OF ENGLAND.

The inventions of Watt and Trevethick; the development of the steam engine, with all its consequential powers; the construction of the locomotive, and the creation of the railroad by Stephenson, are directly the work of England and of Englishmen. These discoveries have made that system of railway and service of ocean steamers which have brought the nations of the earth together, have made new lands accessible and of service to man, and are destined in due time to diffuse knowledge and civilization into every quarter of this globe.

The puddling furnace of Cort, and his method of rolling the puddled blooms in grooved rolls, produced wrought iron in quantities and at a cost hitherto unattainable. Through these inventions South Wales became the seat of the rail trade, and it was enabled for many years to dominate and control the rail trade of the world. The puddling furnace continued, from the latter part of the last to the middle of the present century, to be the instrument by which practically all the malleable iron in the world was made.

The hot blast process of Neilson, patented in 1828, secured a great economy of fuel and a large increase of production. It entirely changed the condition of the pig iron manufacture, and was truly ranked by Mushet as "a means of developing the national wealth of equal value with Arkwright's invention of cotton spinning."

The economy effected in the use of coal in the various processes of the manufacture of iron and steel has been great and progressive. The margin for economy which then existed has been narrowed. But still when you know, on the authority of Sir Lowthian Bell, the duty performed is by no means equivalent to the whole of the useful effect which coke is capable of affording. "Taking a ton as being able to produce 20 cwt. of pig iron from Cleveland ironstone, this, after an allowance for ash, etc., when burned to carbon dioxide, represents 147·200 calories, whereas something like 90·000 calories has been the limit of the power obtained." This sacrifice of 40 per cent. lends itself to reduction, as does the heat held in the stream of molten slag flowing from the furnace.

RAPID DEVELOPMENTS IN IRON.

Nasmyth's steam hammer gave the means of forging which led to rapid developments and improvements in the applications of iron. The reversing rolling mill engine of Ramsbottom has been invaluable in the rolling of plates and bars of great dimensions. The forging press, too, has been designed and improved by English inventors—to whom the world owes much for other mechanical appliances devised to meet the various wants of the Bessemer process and the treatment of masses of iron and steel.

To you probably the most important invention of modern times has been that of Sir Henry Bessemer. It has given you a material in quality and quantity for your railroads which it was a physical impossibility to obtain by the ancient methods of iron making. It is no exaggeration to say that without the Bessemer process for steel rail making, the present railway system of the United States would not now exist; and the settlement of the new lands you have peopled, and the binding together of the vast territory between the Atlantic and the Pacific under one civilized power, would not yet have been effected.

Sir Henry Bessemer has been kind enough, at my request, to prepare, for communication to this meeting, an account of his discovery of the process for manufacturing what is known as Bessemer steel; and some history of his investigations, and the way in which step by step he overcame the difficulties he met with, and finally dispersed, in his developments of his remarkable invention.

The Siemens-Martin process for the manufacture of open hearth steel met with its greatest development in England, and it has enabled us to produce a material suitable for the requirements of the shipbuilder—of which he has availed himself to a vast extent.

GREAT BRITAIN'S OUTPUT OF STEEL.

In Great Britain the production of Bessemer steel ingots in 1889 was 2,140,791 tons; of open hearth steel ingots, 1,429,169 tons. We in Great Britain and Ireland are justly proud of our mercantile marine. The supremacy of our shipbuilders and of our shipping interest is based upon the excellent quality and the abundant supply at a moderate price of steel furnished by our steel makers.

The demands of naval architects and marine engineers have been responded to with intelligence and enterprise. Plates, frames, shafts, forgings, steel castings of forms and dimensions thought impossible but a few years ago have been manufactured at low prices. These productions have enabled our naval architects to design, and our builders to construct, the magnificent ships which are the pride of our navy and our mercantile marine.

The strength of our position and the remarkable economy of this important industry can be best demonstrated to you by a fact within my own personal experience. I have, within the past two months, as chairman of a shipping company, entered into contracts for the purchase of several new first class cargo steamers, to be built of steel, of the most improved design, with triple expansion engines, at the cost of £7 per ton registered tonnage. These ships, of a carrying capacity of 4,000 tons, will be built and afloat within a few months from the laying of the keel. This example will suggest to you that our methods must be economical, and that great attention is given to economy of management. For this we are much indebted to the researches of our chemists, not only in England, but also in Germany and France. An interesting example of which is the use of basic slag as a manure.

This was first applied as a manure in England in the summer of 1885 by Prof. Wrightson, of Downton, Salisbury, who was employed by the Northeastern Steel Company to make a series of experiments. The results were so satisfactory that basic slag immediately became a marketable article instead of a waste product.

Now in the twelve months ending June, 1890, 103,680 tons were delivered from works in Great Britain. Owing to the very much more rapid development of the basic process in Germany, a very much larger quantity of slag has been produced, and during the past three or four years, not only has the whole make been utilized, but stocks have been used up, as well as a considerable proportion of the total quantity exported from England. The make of basic slag in Germany is estimated as about 325,000 tons for the year 1889.

SOME OF THE ALLOYS OF STEEL.

The alloys of steel with other metals continue to be the subject of research and experiment. Many of our members have devoted earnest attention to this fruitful field of inquiry. Communications by Mr. Riley, Mr. Hadfield, M. Osmond, and others, will shortly come before the members, in papers or notes, in the *Transactions* of the Institute. It may be stated in general terms that, owing to the high cost of aluminum, it cannot at present come into extensive use.

Mr. Hadfield and M. Osmond agree that iron with silicon and iron with aluminum have many points of resemblance. But when the addition of 0·15 of aluminum, the minimum amount that has been found efficacious, means an addition of from 12s. 6d. to 20s. per ton on the cost of steel ingot, its employment in competition with silicon, as "ferro-silicon," or "silicon spiegel," cannot be more than experimental.

I hear, however, an American company promises the production of aluminum at a much lower cost than the cost of a year ago, and that a German chemist, now living in Chicago, promises to produce it at a cost of about 7d. per pound.

The remarkable success which has rewarded the researches of inquirers and experimenters on the alloys of steel with chromium, tungsten, aluminum and nickel, gives us good reason to stimulate our members to continue their exploration of this field. Among these alloys the most important results appear to have been obtained from the use of nickel as an alloy of steel.

It will be remembered that when Mr. James Riley's valuable communication on the subject of the alloys of nickel and steel was read before the Iron and Steel Institute meeting in May, 1889, Mr. J. F. Hall, of Messrs. Wm. Jessop & Sons, Sheffield, at once rose and laid claim to priority of invention, informing the Institute of the innumerable experiments he had been making with alloys of nickel and steel during several years past. Since then, continuous experimental research has been made into this matter. Under the superintendence of Mr. Hall, armor plates have been manufactured from this material and tested by English Admiralty officials, giving results which rank about 75 per cent. above any similar plates ever tested in England.

GOOD RESULTS IN ALL TESTS.

During the same period Messrs. Schneider & Co., of Le Creusot, France, have furnished nickel steel armor plates which have been tested by the French, Danish and Chilian Admiralty authorities, with results almost identical with those obtained by Mr. Hall. Within the last month a nickel steel armor plate of Mr. Schneider's manufacture has been tested in the United States, and has given similar results. At the present time Mr. Hall has under course of manufacture breech-loading ordnance cannon and projectiles for the English war office, and he has already applied it in the production of rifle and sporting gun barrels, boiler tubes for torpedo boats, telephone and telegraph wire. When it is considered that nickel steel can be made in various tempers, giving tensile strain of 107 tons per square inch, with an elongation of 3 per cent. in 8 inches; 97 tons tensile, with an elongation of 7 per cent.; 50 tons tensile, with an elongation of 45 per cent., it is impossible to foresee to what uses this most remarkable material may not be put. And now that the various patents and interests owned by Mr. J. F. Hall, of Sheffield, W. H Marbeau, of Paris, William H. Schneider, of Le Creusot, and Mr. James Riley, of Glasgow, have been associated, their joint labors promise to give rapid development to this interesting alloy. Works have already been erected by this association in France for the special manufacture of ferro-nickel, and will shortly be followed by others in England and in the United States of America.

CONTINUAL EXPERIMENTS MADE.

Since Mr. James Riley's valuable communications on the subject of the alloys of nickel and steel, continu-

ous experimental research has been made into this matter.

The treatment of large masses of steel by tempering, hardening, and annealing, in water, oil, or molten metal, has been carefully studied, but the secrets of the behavior of masses of steel in heating and cooling are yet far from being unfolded. M. Osmond, in his excellent paper delivered before the International Congress in Paris last year, points out that tempering in oil was known to the ancients—being mentioned by Pliny. And Shakespeare also knew that the Moors had the knowledge that different temperatures of water affected the results of the hardening process. Othello says: "I have another weapon in this chamber. It is a sword of Spain, the ice brook's temper." One day, in conversation with Mr. Gladstone, I related this to him. He at once capped the quotation by saying:

"Yes; and I remember that Homer, in the Odyssey, says: 'As when the smith dips into cold water a great ax or an adz, and it hisses loudly as he is tempering it, for so it is that iron is made hard.'" (Odyssey, ix. 391 4.)

I have ventured to make a passing mention of some of the men and of some of the inventions which were conceived and brought forth in our island home. I have named some of the inquiries and experimental researches which are being conducted by our metallurgists. You will see that we have need of many precious metals which your prolific country contains, to enlarge the properties of the materials demanded by our engineers, our army and navy, our ship and bridge builders. It is fortunate that we can make known these wants to men like the mining engineers of the United States, whose knowledge of those materials and their localities is as wide as their continent. We need these metals; we need also to feed and clothe our vast industrial population. For your grains and fruits, your cattle and cotton, your remarkable mechanical devices, we have no precious metals to offer in return, but we have the products of our mines, the labor of our looms, the service of our mercantile marine. It is well that we should meet thus, eye to eye and voice to voice, to discuss the interests and the scientific aspects of the great industry which absorbs us. It is thus we learn that by persistent and intelligent labor how much has been accomplished, how much more remains to be achieved, and that by free exchange of ideas and of productions friendly understanding is promoted, and personal acquaintance is built up. Through such orderings we are convinced that Providence has designed to wind the silken chain of commerce around the world. [Applause.]

BESSEMER DESCRIBES HIS STEEL PROCESS.

At the conclusion of his address Sir James Kitson read a long and interesting letter from the veteran metallurgist, Sir Henry Bessemer. Following is an excerpt:

It is with great pleasure that I accede to your request to furnish you with a brief outline of the circumstances which led to the invention of my steel process. At the time of the Crimean war I had invented a mode of firing elongated projectiles from a smooth bore gun, the rotation necessary to insure their proper position during flight being obtained by utilizing a portion of the powder gas to produce rotation by reaction, after the manner of producing rotation in turbines, and not by the rifling of the gun, consequently rendering all smooth bore guns at once suitable for firing elongated shot or shell. I of course offered this plan to our own government, but it was discarded without a trial.

A little after this period I happened to be on a visit for a week or two with Lord James Hay, at the house of his daughter in Paris. During this visit our host gave a farewell dinner to General Hamlin and several other distinguished officers in the French army who were going out to the Crimea.

Among the guests on this occasion was Prince Napoleon, and while taking a cigar in the library after dinner, the conversation turned naturally enough on artillery, and I then mentioned my system of firing elongated projectiles from smooth bore guns. The prince was so impressed with the importance of this idea that he said he was sure that his cousin, the Emperor, would be much pleased if I would explain my invention to him, and that he would get an appointment made with the Emperor for this purpose. This was done, and I had a long and most interesting discussion with his Majesty, whom I found most thoroughly conversant with the whole subject of artillery. His Majesty, in the kindest possible way, gave me a carte blanche to make any experiments I desired at Vincennes.

BESSEMER'S EARLY EXPERIMENTS.

A great many 30-pounder elongated projectiles were made, and were fired from a 4½ inch 12-pounder smooth bore cast iron gun at the Polygon at Vincennes. They were fired through a succession of thin wooden targets placed 100 meters apart, through all of which they cut circular holes, thus showing that they went end on: a thin coat of black japan had been purposely put on them, and when the shots were recovered from the bank in which they were lodged, the coat of japan was seen to be partially scraped off in spiral lines, caused by their passage through the wooden target; the angle of these scratches being carefully taken, showed that from 1½ to 2¼ rotations had taken place in the length of the gun.

After many hours' practice, on a cold December day, we retired to the officers' quarters in the old fortress at Vincennes, and while standing around a blazing wood fire, sipping some hot spiced wine, Commandant Minie (the inventor of the rifle) observed that, "Although the rotation of the shot was effected, unless we had something better to make our guns of, such heavy elongated projectiles could not be used with safety." This casual observation was the spark that has kindled one of the greatest industrial revolutions that the present century has to record, for during my solitary ride in a cab that night from Vincennes to Paris, I made up my mind to try what I could do to improve the quality of iron used in the manufacture of guns.

My knowledge of iron metallurgy was at this time very limited, but this was in one sense a great advantage to me, for I had very little to unlearn, and so could let my imagination have full scope. After many months of trial and much building up and pulling down of reverberatory furnaces, I cast a small model gun; the iron was very white, and in turning it, little short curly shavings were cut off. It was wonderfully tough for cast iron, but wonderfully brittle if classed as wrought iron. The little model gun looked very beautiful when highly polished, and I took it to Paris and begged the Emperor to accept it as the first fruits of my studies of the metallurgy of iron. He expressed himself much pleased with it, and complimented me on having achieved a step in the right direction, and with his own hands placed it in a bureau, saying, "Some day it may become an interesting relic."

BESSEMER—THE EVE OF DISCOVERY.

About this period I began to fully appreciate the fact that if I could improve cast iron and render it malleable, and still retain its fluid state, that apart from its use for artillery it would be of the greatest commercial value for all engineering purposes. I therefore pursued my experiments with greater ardor than ever, for I was convinced that I was on the eve of producing a quality of metal that would supersede wrought iron. I consulted Mr. George Rennie, the eminent civil engineer. I showed him a small upright fixed cylindrical converter, and in it we made a charge of 700 pounds of Blaenavon pig iron into an ingot of malleable iron. Mr. Rennie was in raptures with the result, and said: "You must not keep this light under a bushel for a single day longer; and, by the bye, there is a first-rate opportunity for you. The British Association meet at Cheltenham next Tuesday. Read a paper there by all means. I am president of the mechanical section; it is true all the papers are arranged, but if you will write a paper, I will take the responsibility of putting it first on the list." He kept his promise, and I read my paper "On the Manufacture of Malleable Iron without Fuel."

The entire iron trade of the kingdom was startled by the facts detailed in this paper, backed as they were by two small bars of malleable iron, one of which had been piled and rerolled; a few days later the iron masters came trooping up to London to see the new process. There are many interesting incidents connected with these visits which I cannot trespass on your time to relate; but some idea of the excitement may be gathered from the fact that, notwithstanding the imperfect state of the process at that time, I was actually paid £27,000 for licenses granted within one month of the reading of my paper. At many iron works the managers set to work to test the invention in the rudest possible manner, with such means as they had at their disposal, all of which attempts were failures. In my experiments I had used Blaenavon pig iron, which was successful, and at that time I had no idea that other brands of iron would fail in the manner they did. No sooner were these failures known than an extraordinary revulsion of feeling was manifested, and the most perfect distrust of the invention became universal. The public press, which had spoken of it in such glowing terms, now condemned it as impracticable, and spoke of it as "a brilliant meteor that had flitted across the metallurgical horizon, dazzling a few enthusiasts, and then vanishing forever in total darkness."

THE FUTURE OF IRON.

Sir Lowthian Bell was next introduced. His paper on the "Probable Future of the Manufacture of Iron" was listened to with close attention. He said:

With the exception of air and water, it is open to question whether there is any form of matter which the human race could less easily spare than iron. Short of going the length of asserting that, without this metal for an anchor or steel for the compass, the adventurous navigator could never have crossed the wide Atlantic, we may credit the locomotive and the steamer, and hence iron, for that sequence of events which has peopled North America with the Anglo-Saxon race. The result has been to raise a vast territory to a position without a parallel in the progress of the world.

To the attractions afforded by this interesting episode from modern history may be added the unprecedented development, in the United States, of that branch of industry which most concerns this society.

Let me here remind you, although we are guests upon the present occasion, and Great Britain is the birthplace and home of the Iron and Steel Institute, its name and constitution were intentionally adopted so as to exclude geographical boundaries from being any limit to the scope of its operations. Accordingly these cosmopolitan intentions have been followed by our numbering in our ranks considerably above 200 members belonging to other countries, and of these, nearly one-half are inhabitants of the United States. This union between members of one great family is a subject of sincere congratulation to the founders of the body, and, I feel sure, is not without interest to those who have joined it from the continent of Europe.

The present assembly is, so far as my reading goes, without a precedent in the annals of industry. Manufacturers of a metal from the Old World, where, in spite of what has been said by some antiquarians to the contrary, iron has probably been made for thousands of years, have accepted a courteous invitation from those of the New, with a view to discuss questions of interest common to both. To carry out this intention, three representatives from each hemisphere have been deputed to prepare subjects for this International Congress, and I shall always consider my having been chosen by the Council of the Institute to act on their behalf as a very high and flattering distinction.

ANCIENT HISTORY OF IRON.

Sir Lowthian then discussed the ancient history of the iron trade. He referred to the isolated barbarians found near the great African lakes as being familiar with a mode of obtaining iron with a Catalan fire and a pair of bellows. He traced the progress of metallurgy through its stages, and referred to the various degrees through which the science passed down to the present day. Continuing, the speaker proceeded:

Many eminent metallurgists have regarded with favor the principle contained in a variety of the processes known as "direct," and it must be admitted that there is, in the idea, a simplicity as compared with the present mode of manipulation which is highly attractive. In the latter, the iron from the blast furnace has been made to unite with certain metalloids, we knowing at the same time that, in order to render the product malleable, these substances have to be removed. Among those who have labored in this field, not the least distinguished was my late friend, a former president of this Institute, Sir William Siemens. In the hope of solving a problem in which his predecessors had not been successful, he spared neither time nor money. Ritter Von Tunner, a high authority in all things connected with iron, has, in our frequent correspondence on such matters, extending over many years, expressed himself at one time hopefully on the direct process. In a recent communication, however, he seems to have abandoned all expectation of its being able to compete with the combined forces of the blast furnace and the Bessemer process. On the other hand, so far as I know, Siemens died believing in its future success.

I have elsewhere endeavored to prove that the reduction is not exclusively effected in the so-called reducing zone of the blast furnace; on the contrary, that oxygen, amounting to about 25 per cent. of its original quantity, arrives at or near the tuyeres, combined with iron in the form of some suboxide.

THE ACTION OF CARBON.

Further, that final deoxidation of this suboxide is probably effected by a quantity of carbon, generated by a dissociation of carbonic oxide. This reaction is inferred from the result of numerous experiments in the laboratory and from repeated observations at the furnace itself, confirmed by the fact that the gases at the tuyeres contain a quantity of oxygen, about 2 cwt. per ton of metal produced, and something like 1⅝ cwt. of carbon; the former not being accounted for by the atmospheric air used, nor the latter by the weight of fuel burnt in the hearth. Whether it is the actual carbon precipitated from the carbonic oxide or coke itself which completes reduction or not, in a heat-producing point of view, is immaterial; what seems proved is that it is reserved for the crucible to complete this work at or about the period when fusion takes place.

As a theoretical proposition, we have been reminded that the exact quantity of carbon required to deoxidize 20 cwts. of iron, in the form of ferric oxide, is 4·38 cwts. It is further assumed that this mixture of ore and carbon must be raised to a temperature of 800 deg. C., for which, provided the entire carbon used is burned, half to monoxide and half to dioxide, 1·27 cwts. ought to suffice. It is suggested, not that the work can be done for these 5·65 cwts., but that they are the limits toward which we may work.

So far as my observations, experimental and otherwise, have enabled me to judge, the maximum quantity of oxygen representing the second equivalent in carbon dioxide in the gases is that corresponding with the equivalent contained in the ferric oxide of the ore. From this it might be inferred that reduction is completed in what has been generally known as the reducing zone, *i. e.*, the uppermost and cooler portions of the furnace. We know, however, that the deposition of carbon, accompanied by the generation of some carbon dioxide, as already mentioned, is also most abundant at moderate temperatures

A CONDITION DETERMINED.

These facts might reasonably lead us to expect a quantity of carbon dioxide in excess of that due to the reduction of ferric oxide by carbon monoxide. It will, however, be shown immediately that a condition of equilibrium in the gases is determined, not alone by the relative quantities of the two carbon oxides, but also by the amount of oxygen still remaining in combination with iron. Now, having regard to the quantity of carbon required to be burned at the tuyeres, in order to fuse the slag and iron added to that rendered necessary to reduce the metalloids found in the pig, is such that at the various temperatures through which the ore descends, a position of equilibrium is reached, when the gases contain at the outside about six hundredweight of carbon per ton of iron, in the form of dioxide, and when the metal still retains about one-fourth of its original quantity of oxygen

This observation refers to ores of the type of Cleveland, but with those of a different character the composition of the gases may be materially modified. Thus, in certain Swedish furnaces the fuel consumed does not greatly exceed two-thirds of the quantity necessary for smelting the Cleveland ironstone. The volume of carbon monoxide for every ton of iron is correspondingly diminished, the result being that, instead of having two volumes of this substance in the escaping gases for each volume of carbon dioxide, the two gases are found in almost equal volumes. In one respect, however, all furnaces agree, viz., in there being an increase of carbon and oxygen in the gases at the tuyeres, as compared with that found a short distance above this level.

Thus it will be seen that at no time during the descent of the ore in a properly constituted blast furnace is it, with one exception, ever exposed to a high temperature, in an atmosphere of gases capable of oxidizing iron. The exception is when carbon monoxide is split up into carbon and carbon dioxide; and then the precipitated carbon serves, as has already been observed, to remove the oxygen taken up by the iron during the act of dissociation, when the ore arrives at the tuyeres.

SOME REVERSE CONDITIONS.

Now, it is not too much to say the conditions of every reverberatory furnace are the very reverse of those just laid down. If coal is the fuel burned, which generally is the case we have vapor of water, carbon dioxide, and very often a good deal of free atmospheric air, heated probably at least to 1,500 deg. C., passing over the materials (Of course, it would be quite possible to maintain an excess of the reducing gas—carbon monoxide—in the furnace, but this merely means a great waste of fuel.) Thus exposed, spongy iron, when formed by direct reduction, as proposed, could not fail to be very readily oxidized But the circumstances under which it is now expected to produce spongy iron consists in burning half the carbon to dioxide and the other half to monoxide. From the information contained in the table just given, we learn that, while carbon monoxide is a reducing agent, the product of reduction—carbon dioxide—is of an opposite character, and, in consequence, is able to reoxidize the metallic iron by the production of which it was generated. The cause which determines this reflex action is difference of temperature, and, as might be expected, when both gases are present there is brought about a position of equilibrium, determined, as has been said, not by tem-

perature alone, but also by the extent of the oxygen still remaining united with the iron.

Thus, if a mixture of two volumes of carbon monoxide and one volume of carbon dioxide is passed over calcined Cleveland ore at about 417 deg. C., one-third only of the oxygen can be removed, *i. e.*, the ferric is reduced to ferrous oxide.

If, on the other hand, the gas consists in equal volumes of the oxidizing and reducing gases, the same effect is produced, provided the temperature is raised to a bright red, and spongy iron similarly exposed is oxidized, and becomes also ferrous oxide.

At a white heat the attraction of the metal for oxygen is so intensified that further action ceases when 12 per cent. of the combined oxygen is removed from the ore. At the same time ten volumes of carbon dioxide are able to keep in check the reducing power of ninety volumes of carbon monoxide.

I see no reason, however, why a close approximation to complete reduction, in the direct process, should not be effected by using a sufficient quantity of carbon mixed with the ore, in the manner already described. The difficulty to be apprehended is the reoxidation of the spongy iron when, by the revolution of the furnace a fresh surface is exposed to the flame which is serving to heat the materials under treatment. Certain it is that Siemens failed to reduce the loss of metal to within reasonable limits.

UNABLE TO CHANGE RESULTS.

Forty-five years ago I labored for some time with Mr. William Neale Clay, who was very sanguine of being able to dispense, wholly or partially, with the blast furnace. The results, in our case, were the same as those obtained by others who have followed us in the same path since that time. As regards the carbon required as a source of heat, for raising the temperature of the mixture of ore and carbon, I see no prospect of reducing this with any approach to the quantity previously named, *i. e.*, 1·27 cwt. per ton of iron. Not only theoretically, but practically, in the Bessemer converter, the combustion of the metalloids and a portion of iron suffices to raise the bath of melted cast iron to a proper temperature for keeping malleable iron in a state of fusion. Attempt the same thing in a puddling furnace, rotating or otherwise, and the oxidation of the same metalloids and iron, producing the same quantity of heat as in the converter, requires to be supplemented by the heat afforded by 15 cwt. of coal, in each case commencing with iron in a fluid state. In both there is a great loss of heat at the chimney, but this we will neglect, and regard the remainder in each as due to radiation, convection, etc., inseparable from the larger size of the furnace and the small amount of work turned out as compared with Bessemer's apparatus.

Sir Lowthian, proceeding, discussed the question of the capabilities of a reverberatory furnace, as compared with the united action of a blast furnace, and a Bessemer converter, and the amount of labor required by the two systems.

AN INTERESTING DISCUSSION.

A discussion on Sir Lowthian Bell's paper followed, participated in by Professor Howe, of Boston, G. W. Maynard and Mr. Snelus. Mr Snelus referred to the first attempts made in the direction of manufacturing iron direct from the ore. He said that the element of cost was one that stood in the way of successful results, but that developments would no doubt be brought about which would attach to the direct process more attention than was at present attached to it. He agreed with Sir Lowthian Bell that the blast furnace will still continue to produce the bulk of the iron, and even that required in steel making. Mr. Snelus could not agree with some of the deductions of Sir Lowthian Bell The ex-president, in replying at a later period, handled Mr. Snelus without gloves, and as if he did not like any doubt raised against the stability of any of his arguments.

USES OF ARMOR.

Next came Sir Nathaniel Barnaby's paper on "The Protection of Iron and Steel Ships against Foundering from Injury to their Shells; Including the Use of Armor." Sir Nathaniel in opening said that one-fiftieth of the value of the vessels in the mercantile marine is required annually to make good losses and repairs entailed by collisions alone He said that the security of an iron or steel ship against fatal injury depended upon two things only—size and subdivision.

On the question of armor the speaker said:

Now, in 1890, you have a perfectly regular material, stronger and more ductile than any of this iron, with no trouble as to surface blistering and lamination. You can get Siemens plates of 20 cwt., almost without extras for any increased size, delivered at the ship's side at less than £8 per ton. It has, unfortunately, been as low as £6 5s. This change from iron to steel was not made without a vast amount of anxiety on the part of responsible engineers who led the way.

The result may not be altogether pleasant to the iron and steel makers. To the ship builder and engineer it calls for ungrudging acknowledgment of indebtedness to two eminent British subjects, Bessemer and Siemens, and for the grateful recognition of the enterprise and skill of French, German and British makers. We all owe Germany a lasting debt of gratitude for the birth and training of that true prince—William Siemens. In modern ships of war the main use of armor in the formation of shot-proof decks adjacent to the load water line, and of more or less complete belts of side armor combined with such decks, is to protect the machinery and magazines from shot and shell.

There has been a wide abandonment of side armor, founded upon the recognition of several facts:

WHY SIDE ARMOR WAS ABANDONED.

First.—The increasing penetrating power of the gun. The 12-in gun is now more than a match, at close quarters, for the best 18-in. steel plates. It requires the best 9-in. armor to keep out steel projectiles from the 6-in. gun at short range.

Second.—The great volume and accuracy of shell-fire makes the original arrangement of broadside ports in armored side inadmissible. The crowding of men in the rear of an open or unarmored port can no longer be accepted.

Third.—The propelling machinery and the magazines are of more consequence than the whole battery of guns, because the ship has become, by virtue of her ram and torpedoes, a powerful fighting machine apart from her guns.

Fourth.—The large use of side armor, by reason of its weight and cost, limits the number of ships obtainable with a given sum of money.

But while the side armor has been largely superseded for these reasons, it still possesses one great advantage. It prevents the entrance of water into the zone between wind and water through holes made by light projectiles not capable of perforating armor, but capable of damaging seriously an unarmored side.

Those who have appreciated most keenly the value of side armor at the water line for preserving the floating power of the ship against light guns, have sometimes failed to see that my apparent unreadiness to concur with them has arisen from real sympathy

My contention has been that all armed fighting ships present equal claims to be kept afloat against the attack of the guns which they have to face. I consider that in all such ships the first duty of the designer is to enable the crew to inflict damage on the enemy. Arms and mobility, therefore, come first, endurance under gun fire next. There must be degrees, varying with the size of the ship, in the strength of the arms, and in the amount of the mobility. But all the fighting men, except those in forlorn hopes, are equally entitled to a chance of existence under the artillery fire which they must receive and endure. I have been unable to understand the exclusive claim for protection by means of side armor in a particular class of ships in a large navy, such ships not being distinguished by exceptionally large crews, nor as being centers of operation for a fleet, nor as being required to attack fortresses. And the question as to the use of belt armor in classes of ships not distinguished as above is perplexed by the following considerations:

QUESTIONS OF EXPEDIENCY.

First, and generally, whether in strengthening the water zone by side armor against feeble projectiles, we do not expose it more to the very serious attack of larger ones than it would be if formed with an armored deck near the water. Secondly, whether with a ship of given size and cost we are not sacrificing active offensive qualities for the sake of a passive defensive quality Speed of ship, power of armament, or stored up capital (expended in the ship) may be made to pay too dearly for a passive defense against the invasion of water at the water zone, seeing that the invasion of water beneath that zone becomes a more imminent and more serious peril to the state in proportion to the reduced speed and the increased cost.

So we arrive at an alternative arrangement, a solid raft body at the water zone in place of side belt armor.

It appears that such a raft body can be made which, when undamaged, weighs, with its castings, not more than one-third the weight of water, and which, when saturated, does not exceed the weight of an equal bulk of dry fir.

Such a system of water line defense may prove suitable for all fighting ships, large and small, by reason of its lightness and small cost. As I understand the position, it is proposed to give a trial to this system in the navy of the United States.

I think the time is coming, if it is not already come, when there will be a demand, not only for the recognition of the equal claims of all the fighting ships to be kept afloat against the attack of the guns which they will have to face, but also that their crews between decks should be equally protected against the overwhelming effects of the bursting of high explosives there. For belt and battery armor it is still a matter of debate whether the process of manufacture first introduced, and since most successfully developed, by M. Schneider, or that subsequently devised and manufactured in Sheffield, is the better.

SHEFFIELD'S GREAT EXPERIENCE.

After this paper has left my hands, and before it will be read, there will probably be an interesting series of trials of armor on both plans in the United States; what I say may, therefore, be very brief. Both systems have been in open competition from the beginning, and gun trials have been made by all the maritime powers. The experience of the Sheffield compound armor plate makers as to their own manufacture and that of their rivals has been very great. The amount of steel-faced armor which has been manufactured by them, or by their licensee, during the last twelve years, together with that which is in process of manufacture, equals 112,000 tons.

They urge several considerations in favor of steel-faced armor. They say that steel armor cracks through under blows which are not sufficiently powerful to perforate the plate. They consider that the manufacture of steel armor is less uniform and certain, because it is of very great importance to oil-harden and anneal such armor; and these processes are not required for steel-faced armor. They point out that this treatment can only be applied commercially to large and awkward plates, with great risk, expense, and difficulty, and that under these circumstances a good test plate offers no security as to the quality of the plates it represents. It is conceded that hard-faced armor endures better under oblique blows. They say that a cubic foot of steel armor weighs 492 pounds, whereas a cubic foot of compound armor weighs only 480 pounds—a difference of 2½ per cent. in favor of the latter.

An experiment has recently been made in England to ascertain whether it can be confidently stated that oil-hardening and annealing, or some equivalent finishing process, is necessary for steel plates. Messrs. Brown and Messrs. Cammell, the two great Sheffield firms, makers of compound armor, are satisfied as to this necessity.

A nine-inch plate of steel was manufactured and cut into two plates each four feet square. One piece was left untreated and the other was oil-hardened and annealed. They were fired at by the six inch gun with Firth steel projectiles weighing 100 pounds.

The striking energy of the blow upon the untreated plate was 2,389 foot tons, and the energy of the blow upon that which had been treated was 2,378·5 foot tons. In the latter case the projectile made an indent of 10·5 inches, so that light was just visible through the center of the bulge at the back of the plate. The projectile rebounded, broken into three pieces. The plate was cracked through, but was whole, and no material was splintered out of the front or back of the plate.

In the case of the untreated plate, the shot passed through, and the splintering of the steel round the hole in the front of the plate spread over a space 15 inches across. The splintering round the hole at the back of the plate covered a space 33 inches across. The plate did not remain whole, but went into six separate pieces.

NOT A LOVER OF ARMOR.

I am myself no lover of armor. As a member of a great and peaceful trading community, I dislike everything which, by differentiation, tends to lower the comparative fighting value of armed mercantile ships. I dislike also that which reduces the available number by increasing the individual cost of ships of war.

There is, I think, no such necessary and vital distinction between the man of war and the properly armed and protected state auxiliary of high speed as would justify the neglect of such auxiliaries for maritime warfare. One must admit that at present there are very great differences between them in fighting value, ship for ship, due partly to the very superior subdivision and partly to the use of armor of high quality in the regular ship of war.

The man-of-war proper will probably never abandon the use of armor. We may rather expect that steel and steel-faced armor of the highest quality, instead of being confined to a few ships, called battle ships, will be employed universally for the defense of the absolutely vital parts of every ship built expressly for war service.

Commander Barber, of the United States navy, was called upon by the president to offer any remarks on the paper. He referred to the importance of nickel in connection with the hardening of armor, and said that the time would come when the armor would resist and break the best projectile.

The third paper was by A. E. Seaton, on the "Development of the Marine Engine," and the meeting adjourned.

On the following day visits were made to the most interesting localities and industrial works. For the foregoing reports we are indebted to the *Pittsburg Dispatch*.

INDIAN MOUNDS.

To the Editor of the Scientific American:

Seeing an article in the New York *Herald* in which the writer argued that America was known to some civilized people before it was discovered by Columbus, and basing his argument on the evidences of civilization found in the mounds that are found so numerous along our larger streams throughout the Southern States, and also in the Ohio and Mississippi valleys, and I might say throughout the Northwest as well.

I have been engaged in the explorations of mounds, caves, and burial grounds, of the prehistoric race or races, for five or six years, and in that time have discovered many curious facts that would lead one to believe that whoever constructed these mounds had different objects in view, as some of these mounds contain a great many skeletons, while others contain none at all. And while some are built of alternate layers of earth and charcoal, others are made throughout of the same kind of earth as that immediately around the mound.

I opened a mound in North Carolina that was forty-eight feet in diameter and about nine feet high. At the time I explored it there were five large trees standing on it, one of which measured thirty-four inches in diameter.

I opened this mound by first cutting a trench eight feet wide entirely through the mound from east to west, keeping on a level with the natural surface. On reaching a point near the center of the mound I came upon a stone cist or box in which was a large skeleton lying with its head to the east. This skeleton was in a horizontal position, with the arms lying close by its sides, and around the neck were a great many wampum beads. At the left hand was a very large and well finished pipe made of steatite, and at the right hand were several arrow heads. The stones were built up around the skeleton to a height of two feet, and leaning against the wall near the skull was a large grooved stone ax.

Around this stone cist were seven other skeletons all lying with their heads toward the center, and all resting on a thin layer of coals and ashes. Every skeleton was lying at full length and with their arms close down by their sides, except the skeleton in the east quarter and the one in the northwest quarter. These two were lying with their arms crossed over their breasts. No relics of any kind were found with the seven skeletons outside of the stone cist in the center.

Was this some grand chief that had fallen in battle that was walled up in the center, and those around him seven of his faithful warriors slain to accompany him to the happy hunting ground? Who can tell?

Did the mound builders know or practice the rites or ceremonies of secret societies? is a question asked and argued by some who have made the mounds a study. While I will not attempt to answer the point, I will here give a description of a mound that was explored on the Hiawassee River, on the farm of a Mr. Michael, in McMinn County, Tennessee. This mound stands on the level river bottom, near the mouth of a creek. During the winter of 1889–1890 a high freshet in the river washed the soil off this bottom all around the mound to a depth of two or three feet, and laid bare the bones of a great many skeletons, some of them unusually large. And with these skeletons around the mound were found some fine relics—such as ornamented pottery, pipes, flints, stone axes, etc. The mound standing in the center of this ancient burial ground was about sixty feet in diameter, and at the time it was worked was only six feet high, although the owner of the land told me he could recollect when it was ten or more feet high.

This mound was explored very carefully, and exactly in the center of the mound, on the natural surface, was a large flat stone, and on this stone was a skeleton in a sitting position. Near by the skeleton were three long stones set up in the form of a triangle around the skeleton. No relics of any kind were with this skeleton, but in the east quarter of the mound was a hewn-out stone set up, and on top of this stone was a stone hammer, and behind, or at the outer side of the large stone, was a skeleton in a *sitting* position, with the hand

bones resting on top of the large upright stone. In the south quarter of the mound was another stone set up like the first, with a skeleton in the same position as the other, and resting by the side of this stone was a large grooved stone ax. And in the west quarter of the mound was still another hewn stone set up, and a skeleton by it in a sitting position, with the hands resting on top of the stone in front of it, and near the hand bones of this skeleton were two large ornamented shells and a large flint spear head. The three large stones were all of the same material and shape, placed at about the same distance from the triangle in the center. Behind each stone was a skeleton in a sitting position facing the large stone in front of it, one in the east, one in the south, and one in the west, and nothing in the north. J. W. E.

Bristol, Tenn., Aug. 5, 1890.

ELECTRICITY AS APPLIED TO THE EXTINGUISHING OF FIRES.*

By H. F. LUFKIN.

To speak of electricity as even a possible agent in the extinguishing of fires would seem absurd if we look for our information only in the daily press, which would lead one to believe that the mode or form of motion known as electricity was potent only as an incendiary to instigate conflagration and death. You will readily concede that of all the elements in nature none possesses so wide a range of applicability as electricity. Since its first commercial use by Cook and Wheatstone in their railway telegraph in 1836 and 1838, followed by Morse in 1844, its development has been simply wonderful, especially in the past fifteen years. In the telegraph it is made to convey intelligible characters; in the telephone, articulate sounds; with it metals may be welded, light produced, power distributed, metals deposited by electrolysis, surgical operations performed by electrocautery, nervous systems are toned up by galvanism and faradism, our street cars are operated by it and our steam roads will soon follow, it pumps the organs in our churches, it runs the sewing machine in household and factory, it mines our coal and hauls it out, and why, I may ask, should it not be applied to the extinguishing of fires? Surely it is to-day an important factor in that direction, for does it not, with wonderful intelligence, advise you, not only of the first manifestation of a fire, but of its exact location by means of the automatic fire alarm? Let us go a step further and cause it also to turn the water on, and thus extinguish the fire.

Retrospection in this application of electricity shows us an almost undeveloped field. There has been some work done in the line of electric motors applied to pumps for domestic water supply where the city pressure is insufficient for all domestic requirements; also in the application of electric motors and pumps for supplying water under pressure for hydraulic elevators. As applied to fire department uses, there have been devised a number of electric motors and pumps, or electric pumping engines on trucks, which may be hauled about as the present fire engines are. This involves the necessity of a convenient place for connection with the electric light or power wires of a city at or near each fire hydrant, and also involves the maintenance of an expensive complement of horses as in the present system. The pumping capacity also of any portable engine is, of necessity, limited to a weight and construction which can be readily hauled by a pair of horses with reasonable speed over the varying grades of a city. This, at times, is a serious matter in cities where heavy grades are frequent, especially in the winter time, when streets are obstructed by snow, ice, etc. Prompt response to an alarm is, of course, a necessity, and involves the driving through crowded streets at a speed which is, certainly to the uninitiated, frightful, though singularly free from accident.

In lieu of these portable pumping engines and their several more or less objectionable features, I would submit for your consideration a system of stationary pumping engines, the operation of which I trust I may be able to make clear to you with the aid of these diagrams.

Let me first call your attention to the diagram, Fig. 1, illustrating a stationary system of water distribution for fire purposes under electrical control.

In this diagram, A represents a hydraulic piston, the valves of which are controlled by the electro-magnet, B, the circuit through the magnet, and therefore the piston valves, being controlled by the switches, C C C, etc.

E represents a starting box or rheostat in circuit with the electric motor, F, which is connected by belt or gear to the pump, G. Radiating from the pump, G, is a system of piping connecting to hydrants or plugs, H H H, etc.

The diagram here shown is supposed to represent a city block or square. The pumping apparatus is represented in the center of the block, though it is obvious that it may be placed in any convenient location which may be available and where it will be out of reach of frost, the system of piping being provided with a draw-off valve near the pump, so that the system may be completely drained, if necessary, after use.

The operation of this system is as follows: The hose carriage, with its complement of men, drives up to any of the fire plugs; the hose being attached, the switch, C, is turned. This operates through the magnet, B, and the piston, A, to throw over the switch on the starting box, and thus immediately throws the motor and pump into action. Each district would, of course, be provided with its motorneer, who would attend all fires in his district and care for the motor, pump, etc., during the fire, and whose duty it should also be to daily inspect the apparatus in his district to see that it is kept in proper repair. The motors would in these cases be connected to the mains of some company supplying electricity for light or power, whose charge for this service should certainly be merely nominal.

The water could be drawn from a city supply or from an independent supply provided for fire purposes only. The capacity of these stationary plants also may be equal to the capacity of ten or fifteen engines if necessary, and the motor so connected to the pump that the pressure would remain the same on the system, whether only one stream or the full capacity of the plant were called for. These situations could also be made to cover a considerable territory if desirable, and the several districts included in a general system could be connected together with suitable valves between them, so that they could be operated separately or together, as the exigences of the fire might demand.

A plant of this character, with a capacity of 200 horse power, which would be capable of delivering about 2,500 to 3,000 gallons of water per minute, or say 165,000 gallons per hour, against 150 pounds pressure, could be set up and piped to cover quite a number of city blocks, say ten or fifteen, at an expense of $20,000. The cost to operate this plant at its full capacity would not exceed $10 per hour, or at the rate of 16,500 gallons of water for every $1 of cost. When the fire is out the cost stops absolutely. The wear and tear expense on a large plant of this kind should not be as great as on a single steam fire engine, to say nothing of the cost of maintaining horses and harness.

With this reference to a possible application of electricity to a pumping system for fire department uses, let us see what can be done in the way of protecting isolated buildings. The automatic sprinkler has become a familiar sight in many of our large stores and warehouses, and the reduction in insurance rates wherever these sprinklers are applied is ample evidence of their value. A modification of the system as at present applied suggests itself to me in the use of a motor and pump in place of the roof tank at present in use. The blowing out of a thermostat or other device which now brings the sprinkler into operation could also be made to start a motor and pump, and thus furnish a practically inexhaustible supply of water in place of the limited tank supply now in use. There are, however, numerous recorded instances where these automatic sprinklers have been "too previous," if I may be allowed the expression. In this connection I would ask your consideration of the diagram 2, which illustrates a sprinkler system which, while not automatic in its action, possesses some features of advantage over the automatic system, especially in stores or warehouses which are constantly patrolled, and therefore under surveillance. In this system, the pump, G, and motor, F, are controlled by the same devices of piston, A, and magnet, B, as the system previously described. Connected to the pump and distributed through the several rooms or apartments to be protected is the system of sprinkler piping, H. On each floor, or in each department, if desirable, is situated a valve in a branch from the main piping, controlling the sprinkler system of the floor or apartment. This valve is controlled by a piston, A, and magnet, B, similar to the ones controlling the motor and pump. The several magnets in the building are independently in series with the motor magnet. On each floor, or in any number of places on the floor, are convenient push buttons or switches, C, which being closed act to start the motor and pump and at the same time open the valve in any apartment connected with the switch

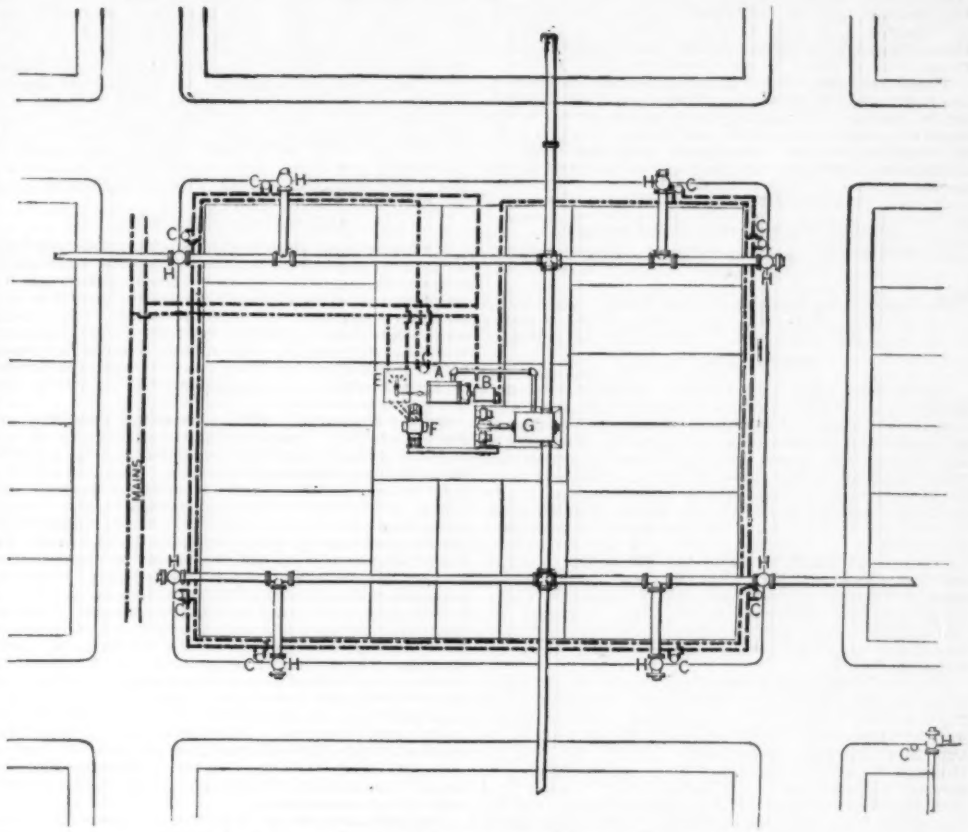


FIG. 1.—ELECTRIC FIRE-EXTINGUISHING PLANT.

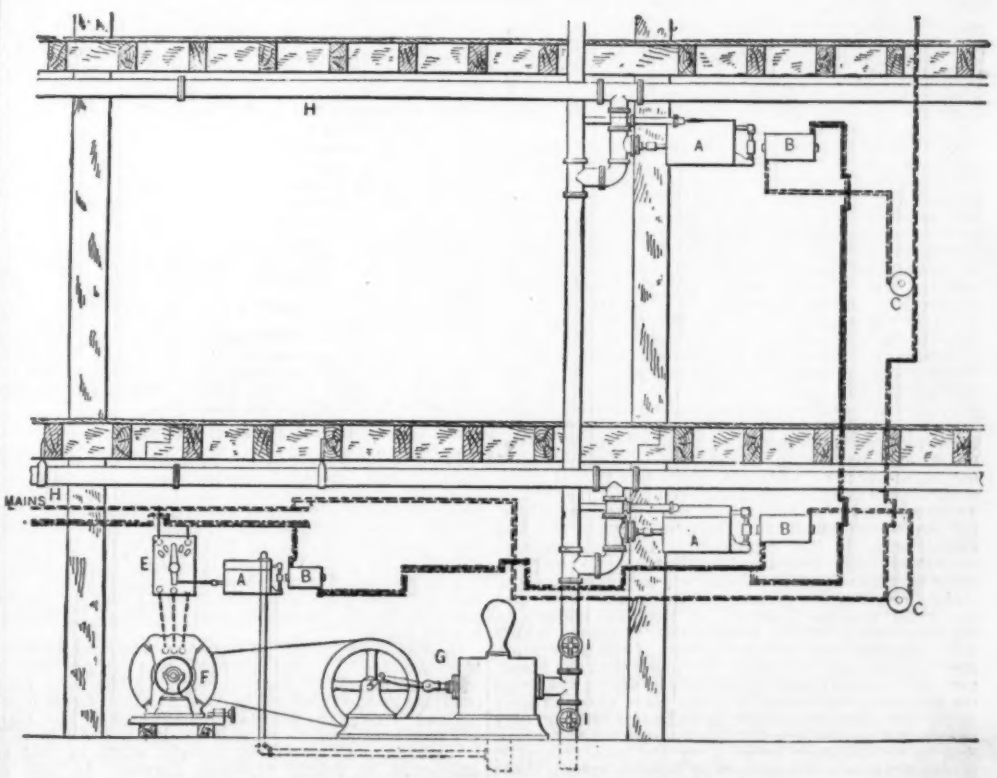


FIG. 2.—ELECTRIC FIRE-EXTINGUISHING PLANT.

* A paper read before the convention of the National Association of Fire Engineers at Detroit, Mich., August 20, 1890.

closed. Where desirable, a second system of switches might be arranged which would act to stop the motor and pump and close the valves.

It seems to me that in a theater a system of this description would be particularly desirable. There could be located in any number of places about the theater sets of switches controlling the entire house. On the discovery of a fire in one of the dressing rooms the sprinkler could be started in the room from any of these several switchboards or in the room itself. In this manner, also, the exits and lobbies could be literally flooded, and thus allow of the harmless escape of the audience, even should the fire practically surround them.

These are some of the possibilities of electricity as applied to the extinguishing of fires, and I submit that, while electricity is making such giant strides in the mechanic arts, its inevitable application as a power for the operation of fire department apparatus is by no means a remote possibility, but will be found an actual necessity.

[Continued from SUPPLEMENT, No. 772, page 12338.]

MEETING OF THE BRITISH ASSOCIATION, 1890.

THE INAUGURAL ADDRESS, BY SIR FREDERICK AUGUSTUS ABEL, C.B., D.C.L. (OXON.), D.SC. (CANT.), F.R.S., P.P.C.S., HON. M. INST. C.E., PRESIDENT.

MINING SAFEGUARDS.

THOSE who have been content to labor long and arduously with the objects steadily in view of advancing our knowledge of the causes of mine accidents and of developing resources and measures for removing or combating those causes can cherish the conviction that recent legislation in connection with coal mines, based upon the results of those labors, has been already productive of decided benefits to the miner, even although it has fallen short of what might reasonably have been hoped for as an outcome of the very definite results and conclusions arrived at by the late Royal Commission on Accidents in Mines (in the recent much lamented death of whose universally respected chairman, my late esteemed friend and colleague, Sir Warington Smyth, the scientific world has sustained the loss of an ardent worker, and the miner, of an invaluable friend).

The fearful dangers arising from the accumulation of inflammable dust in coal mines, and the equality of mine dust with firedamp in its direful power of propagating explosions, which may sometimes even be, in the first instance, established chiefly or entirely through its agency, have now been long recognized as beyond dispute; and it is satisfactory to know that permission to fire shots in mine workings which are dry and dusty has, by recent legislation, been made conditional upon the previous laying of the dust by effective watering. In some mining districts, moreover, the purely voluntary practice has been extensively adopted by mine owners of periodically watering the main roads in dry and dusty mines or of frequently discharging water spray into the air in such roads, which must tend greatly to reduce the possible magnitude of the disastrous results of a firedamp or dust explosion in any part of the mine workings.

The encouragement given to the application of the combined resources of ingenuity, mechanical skill, and knowledge of scientific principles, through the elaborate but thoroughly practical comparative trials to which almost every variety of safety lamp has, during the last few years, been submitted by competent and conscientious experimenters, has resulted in the provision of lamps to the hand of the miner which combine the essential qualities of safety, under the most exceptionally severe conditions with good illuminating power, simplicity of construction, lightness, and moderate cost. Very important progress has also been made, since the first appointment of the late accidents in mines commission, toward the provision of thoroughly serviceable and safe portable electric lamps for use in mines. Of those which have already been in the hands of the miners, several have fairly fulfilled his requirements as regards size, weight, and illuminating power of sufficient duration, but much still remains to be accomplished with respect to durability, simplicity, thorough portability, and cost, before the self-contained electric lamp can be expected to compete successfully with the greatly improved miners' lamps which are now in use or available.

The recent legislation in connection with mines is certainly deficient in any sufficiently decisive measure for excluding from mine workings certain forms of lamps which, while fairly safe in the old days of sluggish ventilation, are unsafe in the rapid air currents now frequently met with in mines. It is, however, very satisfactory to know that the strong representations on this subject made by the late commission, combined with the force of example and with the conclusive demonstration of the superiority of other lamps, by exhaustive experiments, have led within the last two years to the very general abandonment of the unprotected Davy, Clanny, and Stephenson lamps in favor either of simple, safe modifications of these or of other safe and efficient lamps, and that one possible element of danger to the miner has thus been eliminated, at any rate in many districts. In one important respect recent improved legislation has failed to effect a most desirable change—namely, in the substitution of safety lamps for naked lights in workings where small local accumulations of firedamp are discovered from time to time. There appears little doubt that one of the three fearful explosions which have occurred within the last twelve months the explosion at Llanerch colliery, near Pontypool—was caused by the continued employment of naked lights in a mine where inspection constantly revealed the presence of firedamp. This, and two other terrible disasters, at Mossfield colliery, in Staffordshire, at Morfa colliery, near Swansea, which have occurred since the last meeting of the Association may have seemed to weaken the belief that the operation of the recent mines regulation act, which was based upon some of the results of seven years' arduous labor of the late mines commission must have resulted in very substantial improvement in the management of mines, and in the conduct of work by the men. Happily, however, there is a consensus of opinion among those most competent to judge—*i. e.* the government mine inspectors—that very decided benefits have already accrued from the operation of the new act. Although far from embodying all that the experienced mine owners, miners, and scientific workers upon that commission, as well as practical authorities in Parliament, concurred in regarding as reasonably adaptable, from the results of observation and experiment, to the furtherance of the safer working of mines, this act does include measures precautionary and preventive, of undeniable utility, well calculated to lessen the dangers which surround the miner, and to add to his personal comfort underground. We may hope, moreover, that the operation of the act is paving the way to more comprehensive legislation in the near future, for it can scarcely be doubted, by the light of recent sad experience, that there are directions in which both masters and men still hesitate to adopt, of their own free will, measures or regulations, methods of working or appliances and precautions, which are calculated to be important additional safeguards against mine accidents, and which are either left untouched, or only hesitatingly and imperfectly dealt with in the recent enactments.

ACCIDENTAL EXPLOSIONS.

My labors upon the late mines commission represent only one of several subjects in connection with which it has been my good fortune to have opportunities of rendering some slight public service in directions contrasting with one of the main functions of my career, by endeavoring to apply the results of scientific research to a diminution of the risks to which particular classes of the community, or the public at large, are exposed —of being sufferers by explosions, the results of accidents or other causes.

During the pursuit of bread-winning vocations, and even in ordinary domestic life, the conditions, as well as the materials, requisite for determining more or less disastrous explosions are often ready to hand, and their activity may be evoked at any moment through individual heedlessness or through pure accident. Steam, or gases confined under pressure, volatile inflammable liquids, combustible gases, or finely divided inflammable solids, are now all well recognized as capable of assuming the character of formidable explosive agents; but with respect to the three last named, it is only of late that material progress has been made toward a popular comprehension and appreciation of the conditions conducive to danger, and of those by the fulfillment of which danger may be avoided. Thus, the causes of explosions in coal-laden ships, together with the occurrence of spontaneous ignition in coal cargoes, another fruitful source of disaster, were made the subject of careful inquiry some years ago by a royal commission, upon which I had the pleasure of working with the late Dr. Percy, whose invaluable labors for the advancement of metallurgic science will always be gratefully remembered.

The light thrown by that inquiry upon the causes of those disasters, and upon the conditions to be fulfilled for guarding against the accumulations of firedamp, gradually escaping from occlusion in coal, and of heat, developed by chemical changes occurring in coal cargoes, has unquestionably led to an important reduction of the risks to which coal-laden ships are exposed. Subsequent official inquiries and experimental investigations, in which I took part with the late Sir Warington Smyth, and some eminent naval officers, consequent upon the loss of H.M.S. Doterel, through the accidental ignition of an explosive mixture of petroleum spirit vapor and air (and other calamities in war ships originating with the gradual emission of firedamp from coal), have resulted in the adoption of efficient arrangements for ventilating all spaces occupied by, and contiguous to, the large supplies of fuel which these vessels have to carry.

The thorough investigation, by Rankine and others, of the causes of explosions in flour mills, which in years past were so frequent and disastrous, has secured the adoption of efficient measures for diminishing the production of, and the dissemination through channels and other spaces in the mills, of explosive mixtures of flour dust and air, and for guarding against their accidental ignition. The numerous terrible accidents caused by the formation and accidental ignition of explosive mixtures of inflammable vapor and air in ships carrying cargoes of petroleum stored in barrels or in tanks have, by the investigations to which they have given rise, led to the indication of effective precautionary measures for guarding against their recurrence. Again, the many distressing accidents, frequently fatal, which have attended the domestic use of those valuable illuminants, petroleum and mineral oils of kindred character, have been made the subject of exhaustive investigations, which have demonstrated that these disasters may readily be prevented by the employment of lamps of proper construction, and by the observance of very simple precautions by the users of them; and a recent official inquiry which I have conducted with Mr. Boverton Redwood has furnished most gratifying proof that very substantial progress has been made within the last few years by lamp manufacturers in the voluntary adoption of such principles of construction as we had experimentally demonstrated to be essential for securing the safe use of mineral oils in lamps for lighting and heating purposes, the employment of which has, within a brief period, received enormous extension in this and other countries.

THE PETROLEUM INDUSTRY.

The creation and rapid development of the petroleum industry has, indeed, furnished one of the most remarkable illustrations which can be cited of industrial progress during the period which has elapsed since the British Association last met in Leeds. One year after that meeting, viz., on August 28, 1859, the first well drilled in the United States with the object of obtaining petroleum, was successfully completed, and the rate of increase in production in the Pennsylvania oil fields during the succeeding years is shown by the following figures:

In 1859, 5,000 barrels (of forty-two American gallons) were produced. In the following year the production increased to 500,000 barrels, while in the next year (1861) it exceeded 2,000,000 barrels, at which figure it remained, with slight fluctuations, until 1865. The supply then continued to increase gradually until in 1870 it reached nearly 6,000,000 barrels, while in 1874 it amounted to nearly 11,000,000 barrels. In 1880 it amounted to over 26,000,000 barrels, and in 1882 it reached 31,000,000. Since then the supply furnished by the United States has fallen somewhat, and last year it amounted to 21,500,000 barrels. The production of crude petroleum in the Pennsylvania fields, large as it has been, has not, however, kept pace with the consumption, for we find that the accumulated stocks, which on December 31, 1888, amounted to over 18,000,000 barrels, had become reduced to about 11,000,000 barrels at the close of last year. At this rate the surplus stock above ground will have vanished by the end of the current year. In addition to the petroleum raised in Pennsylvania, there is now a very large production in the State of Ohio, but this has not yet been employed as a source of lamp oil. It is, however, transported by pipe line in great quantities to Chicago, for use as liquid fuel in industrial operations.

A few years after the development of the United States petroleum industry, the production of crude petroleum in Russia also began to extend very rapidly. For more than 2,500 years, Baku, on the borders of the Caspian Sea, has been celebrated for its naphtha springs, and for the perpetual flames of the fire worshipers, fed by the marvelous subterranean supplies of natural gas. To a limited extent neighboring nations appear to have availed themselves of the vast supplies of mineral oil at Baku during the past thousand years. By the thirteenth century the export of the crude oil had already become somewhat extensive, but the production of petroleum from it by distillation is of comparatively recent date. In 1863 the supplies of petroleum from the Baku district amounted to 5,018 tons. They increased to somewhat more than double during the succeeding five years. In 1869 and following three years the production reached about 27,000 tons annually, and in 1873 it was about 64,000 tons. Three years later, 153,000 tons were produced, and in the following five years there was a steady annual increase, until in 1882, the production amounted to 677,269 tons. In 1884 it considerably exceeded 1,000,000 tons, and last year it had reached the figure of about 3,500,000 tons. The consumption of crude petroleum as fuel for locomotive purposes has, moreover, now assumed very large proportions in Russia, and many millions of gallons are annually consumed in working the vast system of railways on both sides of the Caspian Sea.

The imported refined petroleum used in this country in lamps for lighting, heating, and cooking was exclusively American until within the last few years, but a very large proportion of present supplies comes from Russia. The imports of kerosene into London and the chief ports of the United Kingdom during 1889 amounted to 1,116,205 barrels of United States oil and 771,227 barrels of Russian oil. During the same period the outturn of mineral oil for use in lamps by the Scottish shale oil companies probably amounted to about 500,000 barrels.

Another important feature connected with the development of the petroleum industry is the great extent to which the less volatile products of its distillation have replaced vegetable and animal oils and fats for lubricating purposes in this and other countries. The value of petroleum as a liquid fuel and as a source of gas for illuminating purposes has, moreover, been long since recognized, and it is probable that one outcome of the attention which is now being given to the hitherto unworked deposits of petroleum in the East and West Indies, South America, and elsewhere, will be a very large increase in its application to these purposes. In the East Indies there are vast tracts of oil fields in Burma, Baluchistan, Assam, and the Punjab. The native Rangoon oil industry is one of great antiquity, although the oil was only used in the crude condition until about thirty five years ago, at which time Dr. Hugo Muller, with the late Warren de la Rue, whose many-sided labors and generous benefactions have so importantly contributed to the advancement of science, made valuable researches on the products furnished by crude oil imported from Rangoon. The resources of the oil fields of Upper Burma, especially of the district of Yenangyoung (or creek of stinking water), have since then been developed by British enterprise, and have attained to considerable importance since our annexation of Upper Burma.

The great extension of the petroleum trade is gradually leading to very important improvements in the system of transport of the material over water and on land. Until recently this has been carried out entirely in barrels and in cases. The consequent great loss from leakage and evaporation, accompanied by risk of accident, is now becoming much reduced by the rapidly increasing employment of tank steamers, which transport the oil in bulk. Tank railway wagons have for some time past been in use in Russia, and there is a prospect of these and of tank barges being adopted here for the distribution of the oil, while in London the practice is already spreading gradually of distributing supplies to tradesmen from tank road wagons. Some considerable doubt as to whether the risk of accident has not rather been altered in character than actually reduced by the new system of transport has not unnaturally been engendered in the public mind by the occurrence within a comparatively short period of several serious disasters during the discharge of cargoes from tank vessels.

The memorable explosion which took place in October, 1888, on board the Ville de Calais, in Calais harbor, with widespread destructive effects, was followed by a similarly serious explosion in the Fergusons, at Rouen, last December, and, more recently, by a fire of somewhat destructive character at Sunderland, resulting from the discharge into the river of petroleum residues from a ship's tanks. In all these cases the petroleum was of a nature to allow inflammable vapor to escape readily from the liquid, so that an explosive mixture could be rapidly formed by its copious diffusion through the air. No similar casualty has been brought to notice as having happened to tank ships carrying petroleum oil of which the volatility is in accordance with our legal requirements, and this points to the prudence of restricting the application of the tank system to the transport and distribution of such petroleum as complies with well established conditions of safety.

NATURAL GAS.

Another most remarkable feature connected with the development of the petroleum industry is presented by the utilization, within the last few years, of the vast supplies of natural inflammable gas furnished by the oil fields.

In America this remarkable gas supply was for a long time only used locally, but before the close of 1885 its

conveyance to a distance by pipes, for illuminating and heating purposes, had assumed large proportions, one of the companies in Pittsburg having alone laid 335 miles of pipes of various sizes, through which gas was supplied equivalent in heating value to 3,650,000 tons of coal per annum. Since then the consumption in and around Pittsburg has probably been at least tripled. At the close of 1886 six different companies were conveying natural gas by pipes to Pittsburg from 107 wells; 500 miles of pipe ranging in diameter from 30 in. to 3 in were used by these companies, 232 miles of which were laid within Pittsburg itself. The Philadelphia Company, the most important of these associations, then owned the gas supply from 54,000 acres of land situated on all the anticlinals around Pittsburg, but drew its supplies only from Tarentum and the Murraysville field. It supplied, in 1886 470 factories and about 5,000 dwellings within the city, besides many factories and dwellings in Allegheny, and in numerous neighboring villages. The average gas pressure at the wells when the escape is shut off is about 500 lb. per square inch, and in the case of new wells this pressure is very greatly exceeded. In order to minimize the danger from leakage the gas pressure in the city is reduced to a maximum of 13 lb., and is regulated by valves at a number of stations under the control of a central station. The usual pressure in the larger lines is from 6 to 8 lb., while in the low pressure lines it does not exceed 4 to 5 oz.

The effect of the change from coal gas to natural gas upon the atmosphere over Pittsburg has been most marked. Formerly the sky was constantly obscured by a canopy of dense smoke; now the atmosphere is clear, and even white paint may with impunity be employed for the house fronts.

The very rapid development of the employment of natural gas is not confined to the neighborhood of Pittsburg; it is used for heating purposes in the cities of Buffalo, Erie, Jamestown, Warren, Olean, Bradford, Oil City, Titusville, Meadville, Youngstown, and perhaps twenty more towns and villages in Pennsylvania and northwestern New York. In northwestern Ohio, the cities of Toledo and Sandusky, the towns of Findlay, Lima, Tiffin, Fostoria, and others in that section are also supplied with natural gas; a pipe line has, moreover, been recently laid to Detroit, Mich., and it is estimated that in these localities 36,131,669,000 cubic ft. of the gas were consumed during last year, displacing 1,802,500 tons of coal. To the southwest of Pittsburg there are many smaller places which consume natural gas; it also occurs in considerable quantity, and is being utilized, in Indiana (whence an account has recently reached us of a terrific subterranean explosion of the gas); and it is at the present time contemplated to carry a natural gas supply to Chicago.

The utilization of the natural gas of the Russian oil fields, although of very ancient date, has hitherto not been extensive, neither does the magnitude of the supply appear to bear comparison with that of the Pennsylvanian district.

WATER GAS.

A form of gaseous fuel which has long been known to technical chemists and metallurgists, but which has of late attracted considerable attention, especially in connection with the recent interesting work relating to its applications pursued by Mr. Samson Fox, of Leeds, has become, within the last four years, a competitor, in the United States, both of the natural gas of Pennsylvania and of coal gas. Since Felix Fontana first produced so-called water gas in 1780, by passing vapor of water over highly heated fuel, many methods, differing chiefly in small details, have been proposed for carrying out the operation, with a view to the ready and cheap production of the resulting mixture of hydrogen and carbonic oxide, and numerous technical applications of water gas have been suggested from time to time, with no very important results, excepting as regards its use for lighting purposes. Being of itself non-luminous, its utilization in this direction is accomplished, either by mixing it with a highly luminous gas or by causing a hydrocarbon vapor to be diffused through it; or the non-luminous flame produced by burning it in the air is made to raise to incandescence some suitably prepared solid substance, such as magnesia, lime, a zirconium salt, or platinum, whereby bright light is emitted. The objection to its employment as an illuminant for use in buildings, to which great weight is attached by us, and rightly, as sad experience has shown—viz., that, as it consists, to the extent of about one-half of its volume, of the highly poisonous gas carbonic oxide, the atmosphere in a confined space may be rendered irrespirable by a small accidental contamination with water gas, by leakage or otherwise, not detectable by any odor—appears to constitute no great impediment to its employment in the United States, as it is now manufactured for illuminating and heating purposes by a large proportion of their gas works, being in some places employed in admixture with a highly luminous coal gas, in others rendered luminous by the alternative methods mentioned. It is stated that about three-fourths of the illuminating gas now supplied to the cities of New York, Brooklyn, Philadelphia, Jersey, St. Paul, and Minneapolis is carbureted water gas; in Chicago the entire supply now consists of this gas, and Boston will also soon be supplied exclusively with it. The use of water gas for metallurgic work does not appear to be contemplated in the United States, but it is especially to such applications of the gas that much attention has been devoted here in Leeds; and although some eminent experts are skeptical regarding the attainment of advantages, especially from an economical point of view, by the employment of this form of gaseous fuel, especially after practical experience in the same direction acquired in Germany, the technical world must feel grateful to Mr. Fox for his work in this direction, affording, as it does, an interesting illustration of the qualities of perseverance and energy which, when combined with sound knowledge, often achieve success in directions that have long appeared most unpromising—qualities which have been characteristic of many pioneers in industrial progress in this country.

PROGRESS OF LEEDS.

Leeds has been especially fortunate in the possession of such pioneers, who, when competition brought about great changes in the particular trade through which, for many generations, this city chiefly enjoyed prosperity and high renown, developed its power and resources in new directions, from which success soon flowed in continually increasing measure. The rapid rise of Leeds to its present high position in industrial prosperity and national importance most probably dates from the period when its chief staple industry began to experience serious rivalry, in its own peculiar achievements, on the part of other districts of the kingdom and of other countries. From early days a flourishing center of one of the provinces of Great Britain most richly endowed with some of nature's best treasures, Leeds could scarcely have failed, through the energy, acute intelligence, and powerful self-reliance especially characteristic of the men of Yorkshire, to rapidly acquire fresh renown in connection with industries which either were new to the town and district or had been pursued in comparatively modest fashion, and which have combined to place the Leeds of to-day upon a higher pinnacle of commercial prosperity, power, and influence than her patriotic citizens of old could ever have dreamt of.

An examination into the present educational resources of Leeds places beyond any doubt the fact that her present prosperity in commerce and industries is in no small degree ascribable to the paramount importance long since attached here to the liberal provision of facilities for the diffusion of knowledge among the artisan and industrial classes, and especially for the acquisition of a sound acquaintance with the principles of the sciences and their applications to technical purposes, with particular reference to the prominent local industries, by all grades of those who pursue or intend to pursue them. There is, probably, no town in the kingdom more amply provided with efficient elementary and advanced schools for both sexes, while the special requirements of the artisan are efficiently met by the prosperous School of Science and Technology. The resources of the Yorkshire College provide, in addition, a combination of thorough scientific education with really practical training in the more important local industries. Indeed, during the sixteen years of its continually progressive work, this institution has acquired so widespread a reputation that students come from abroad to reap the advantages afforded by the unrivaled textile and dyeing departments of the Leeds College. The keen competition now existing between these departments and the corresponding branches of the much younger but most vigorous sister college at Bradford can only conduce to the further development of both, and to their thorough maintenance up to the requirements of the day.

The very important pecuniary aid afforded to these establishments, and to a number of other technical schools in Yorkshire, by one of the most important of the ancient companies of the city of London, the cloth-workers, affords an interesting illustration of the good work in the cause of education performed by those guilds, and, especially of late years, by means of their flourishing institute for the advancement of technical education, which, through its two great instructional establishments in London, and through the operation of its system of examinations throughout the country, extending now even to the colonies, has afforded very important aid toward eradicating the one great blot upon our national educational organization. To have been first in the field in practically developing a far-reaching scheme for the advancement of technical education in this country must continue to be a source of pride to the City of London and its ancient guilds in time to come, when the operation of efficient legislation, supported and extended by patriotic munificence and by the hearty co-operation of associations of earnest and competent workers in the cause, shall have placed the machinery and resources for the technical instruction of the people upon a footing commensurate with our position among nations.

NATIONAL MUSEUMS.

The remarkable address delivered by Owen here in 1858, wherein the condition, at that time, of those branches of natural science which he had made particularly his own was most comprehensively reviewed, included some especially interesting observations on the importance to the cultivation and progress of the natural sciences, and to the advancement of education of the masses in this country, of providing adequate space and resources for the proper development of our national Museum of Natural History, and it cannot but be a source of great satisfaction and pride to him to have lived to witness the thoroughly successful realization of the objects of his own indefatigable strivings and powerful advocacy in that direction. Comprehensive as were the views adopted by Owen regarding the scope and possible extension of that museum, it may, however, be doubted whether they ever embraced so extensive a field as was presented for our contemplation by his successor last year, when he told us that a natural history museum should, in its widest and truest sense, represent, so far as they can be illustrated by museum specimens, all the sciences which deal with natural phenomena, and that the difficulties of fitly illustrating them have probably alone excluded such subjects as astronomy, physics, chemistry, and physiology from occupying departments in our national Museum of Natural History.

The application, in its broadest signification, of the title Natural History Museum may doubtless be considered to include not only illustrations and examples of the marvelous works of the Creator and of the results of man's labors in tracing their intimate history and their relations to each other, but also illustrations of the means employed, and of the results attained, by man in his strivings to fathom and unravel the laws by which the domains of nature are governed. But the reason why representative collections illustrative of the physical sciences do not form a part of our national Natural History Museum has, I venture to think, scarcely been directly ascribable to any difficulty of organizing fit illustrations of methods of investigation, of the attendant appliances, and of the results obtained by experimental research. It appears, rather, to exist in the fact that physical science has hitherto had no share in such a combination of circumstances as has been favorable to the good fortunes and advancement of the natural sciences, and as is analogous to those which, from time to time, give rise to the provision of increased accommodation for our national art treasures. Our present national science collection, which has indeed, had a struggle for existence, does not owe the development it has hitherto experienced to any such moral pressure as has been several times exercised in the case of our art collections, by the munificence of individuals, with the result of securing substantial aid from national resources. Its gradual increase in importance has been due to the untiring perseverance of men of science, and of a few prominent, influential, and public-spirited authorities, in keeping before the public the lessons taught by careful inquiries, such as those intrusted to the royal commission on scientific instruction, into the opportunities afforded for the cultivation of science and the development of its applications, in other countries, as compared with those provided here.

The success of the efforts made in 1875 by a committee thoroughly representative of every branch of experimental science, to bring together in London an international loan collection of scientific apparatus, and the widespread interest excited by that collection, led the president of the Royal Society in union with many distinguished representatives of science, to lay before our Department of Education a proposal to establish a national museum of pure and applied science, including the Museum of Inventions, which had already existed since 1860 as a nucleus of a science museum, the establishment whereof had formed part of the original scheme of the Science and Art Department. The loan collection of 1876 did, in fact, and in consequence of the urgent representations then made, first put into practical shape the long-cherished desire of men of science to see an institution arise in England similar to the Conservatoire des Arts et Metiers, of France, and it became the starting point of the national collection, representative of the several branches of experimental science, which has been undergoing slow but steady development since that time, patiently awaiting the provision of a suitable home for its contents. This collection, which illustrates not only the means whereby the triumphs of research in experimental science have been and are achieved, but also the methods by which these departments of science are taught, yields, small as it is, to none of our national museum treasures in interest and importance.

In yet another way did that loan collection become illustrious: one of the most interesting features connected with it was the organization of a series of important conferences and explanatory lectures, serving to illustrate, and also greatly to enhance, its value, and affording most invaluable demonstration of the way in which such collections must exercise direct influence upon the advancement of science and upon the diffusion of scientific knowledge. These lectures and conferences demonstrated the wisdom of the suggestion made by the illustrious representative of associated science in Leeds eighteen years previously, that public access to museums should be combined with the delivery of lectures emphasizing and amplifying the information afforded by their contents. The example there set of thoroughly utilizing for instructional purposes, and for the advancement of science, a collection illustrative of the physical sciences, has since been followed by the Science and Art Department. Illustrative lectures connected with the existing nucleus of a national science collection have been delivered from time to time, and the objects in the collection are constantly utilized in the courses of instruction of the adjoining Normal School of Science.

Although the national importance of thoroughly representative and continuously maintained science collections has long been manifest, not only to all workers in science, but also to all who have cared to inquire, even superficially, into the influence of the cultivation of science upon the industrial and commercial prosperity of the country, the labors of a royal commission, and of successive committees, in demonstrating the necessity for the provision of adequate accommodation for such collections, and for their support upon the basis of that afforded to the natural history collections, have been very long in bearing fruit. However, lovers of science, and those who have the prosperity of the country near at heart, have at length cause for rejoicing at the acquisition by the nation of a site in all respects suitable and adequate for the accommodation of the science collections, which, as soon as appropriate buildings are provided for their reception, will not fail, in comprehensiveness and completeness, to become worthy of a country which has been the birthplace of many of the most important discoveries in science, and of a people who have led the van among all nations in making the achievements of science subservient to the advancement of industries and commerce.

The site selected as the permanent home of our national science collections is immediately in rear of the Natural History Museum, and faces the stately edifice, now rapidly progressing toward completion, for the erection of which, as an imperial memorial of the Queen's Jubilee, funds were provided by voluntary contributions from every portion of the empire and every class in the empire's nations. The Imperial Institute, the conception of which we owe to his Royal Highness the Prince of Wales, occupies a central position among buildings devoted to the illustration and cultivation of pure and applied science and of the arts—*i. e.*, the Normal School of Science, the Technical College of the City and Guilds of London, the National Schools of Art, the Science Museum, the South Kensington Museum, and the Royal College of Music; to which we may ere long see added a national gallery of representative British art. A more fitting location could scarcely be conceived for this pre-eminently national institution, which has for its main objects the comprehensive and continuously progressive illustration of the practical applications of the vast resources presented by the animal, vegetable, and mineral kingdoms to industries and the arts; of the extent and the progressive opening up of those resources in all parts of the empire; of the practical achievements emanating from the results of scientific research; and of the utilization of the arts for the purposes of daily life. With the attainment of these objects it will be the function of the Imperial Institute to combine the continuous elaboration of systematic measures tending to stimulate progress in trades and handicrafts, and to foster a spirit of emulation among the artisan and industrial classes. Another branch of the institute's work, upon which it is already engaged, is the systematic collection of data relating to the natural history, commercial geography, and resources of every part of the empire, for wide dissemination, together with all current information bearing upon the commerce and

industries of the empire and of other countries, which can be comprised under the head of commercial intelligence. The achievement of these objects should obviously tend to maintain intimate intercourse, relationship, and co-operation between the great home and colonial centers of commerce, industries, and education, and to enhance importantly our power of competing successfully in the great struggle in which nations are continuously engaged for supremacy in commercial and industrial enterprise and prosperity.

To the elaboration of the practical details of a system of operation calculated to secure the objects I have indicated, eminent public-spirited men are now devoting their best energies, with the sanguine expectation of realizing the hope cherished by the royal founder of the Imperial Institute, that this memorial of the completion, by our beloved sovereign, of fifty years of a wise and prosperous reign, is destined to be one of the most important bulwarks of this country, its colonies and dependencies, by becoming a great center of operations, ceaselessly active in fostering the unity and developing the resources, and thus maintaining and increasing the power and prosperity of our empire.

STREET WATERING WITH SEA WATER.

CONSIDERABLE attention has been given to the subject of watering roads, and it has been asserted very strongly that sea water should be used in all seaside towns—first, because it is more economical; and secondly, because of its capability of binding the surface of the roads. A great deal is made of the fallacious assertion that seaside towns have a limited supply of water during the season, when the population is mostly doubled, but in the papers read before scientific societies, and the notices which appear in the technical journals, there is no attempt made to tabulate the towns which run short of water during the summer months. The number of towns using and advocating the use of salt water is about twenty-six, three of which are only known to have an inadequate service of pure water, and are ill-advised in laying out large sums of money to pump sea water, when the same outlay would have procured an abundant supply of pure water for the inhabitants for many years to come.

An argument is sometimes adduced, representing the water company as being antagonistic to the local authority, inasmuch as the latter is desirous of introducing another water company to sell salt water instead of fresh, for the purposes for which the original company had been granted parliamentary powers. This is parallel to the water gas crusade—seeking powers to lay down plant and distribute this poisonous stuff at a cheaper rate than the original gas company. If a local authority desires to have dirty water distributed throughout the town, the water company, having all the plant at hand, could readily sink shallow wells and pump surface water, or sea water, cheaper than the authorities could erect new pumping plant and lay distributing mains for the purpose. Of course, the whole of the evidence is obtained from corporation officials, who were loud in their promises—before the water undertaking was purchased—to sell water by meter; but in no instance has this supposed boon been granted to the public.

The figures quoted by the officials, compared with those obtained by the officials of water companies, are entirely different; as are also the statements made as to the use of sea water, which is said to be conducive to health, but in what manner is not fully explained. The registrar-general's report does not show this result. Besides the large amount of salts contained in sea water, there is a considerable quantity of glutinous sap derived from decaying seaweed washed up by the storms. This glutinous mess, left on the surface of roads, has a tendency to bind the macadam, but most of the advocates of sea water state that for every two loads of salt water there should be one of fresh water, perhaps to wash away these impurities, or rather to lessen them. In one instance the streets are watered twice during the day—once with fresh, and once with salt water, as the rising ground would become too slippery if sprinkled twice with salt water. The general rule is not to use salt water on roads where the gradient is (say) 1 in 20, as they become greasy, and horses cannot stand on them. Such roads are sadly deteriorated, and become as rotten as possible in winter. Swamping wood pavements with salt water makes them exceedingly slippery. If used for flushing sewers, a very large volume of water must be employed, as small quantities of sea water mixing with the sewage have a tendency to produce noxious gases, and serious complaints are soon heard. The street watering is confined to just three months in the year; and the lowest estimate of the cost of pumping is 4d. per 1,000 gallons, while the very high parts of the town are usually watered from the street hydrants as before.

More than half the towns which once employed sea water have discontinued its use. Now, if it is of such great worth to the community some would make out, is it likely that upward of 50 per cent. would be found giving it up because they could not extend their works for such a purpose? All towns are subject to some little neglect in the height of the season, owing to the staff of workmen being overtaxed; and in the extremely hot weather it is not desirable to pour salt water on roads not thoroughly well scavengered. All engineers who may have selected and visited the most popular seaside resorts during the hottest months of the year, for the express purpose of deciding which water is preferable to sprinkle over the roads, will not hesitate to give the preference to the present method, not only in regard to the health of the visitors, and the general sanitary condition of the town, but also to the comfort of the inhabitants. As to the evaporation of salt water from the street surface injuring cutlery, jewelry, and fine metal goods, etc., exposed in shop windows, as well as locks, fittings, and fine art treasures in houses, there cannot be two opinions; and the effect is much greater when all the streets are swamped with a saline mixture. The engineer of the principal town in which sea water is used acknowledges that it disintegrates granite macadam roads.

The advocates of the salt water system base all their figures on the cost of 1s. per 1,000 gallons. This is a most inaccurate estimate, as the average of all the most important seaside towns amounts to just 9¼d. per 1,000 gallons. On private inquiry I find that the majority of companies have a special low charge for street watering and flushing. If town officials, in their wisdom, should elect to put the ratepayers to the expense of another water supply, surely they ought first to count the cost, when it would certainly be found that the present system is most economical. If the town is suffering from an insufficient supply, it would still be preferable to expend money in extending the works, and to sell a supply of water for the same amount as the ratepayers would be saddled with if a second plant were to be purchased. The highest lift in the towns referred to is 50 feet. Now, in many cases and in most of the new and progressive seaside resorts which are at present paying but 6d. to 8d. per 1,000 gallons, from 300 to 400 feet must be attained to water the hillside streets. Nothing is said about the deterioration of plant—mains, cocks, hydrants, water vans, stand pipes, tower, etc. Neither is anything said of the kind of meter used to measure the quantity supplied to baths. I used the ordinary inferential meter once for filling carts with salt water, and it did not last a month.

I have visited the towns where sea water is in use, and have made strict inquiry from people constantly driving over the roads, and they are loud in condemnation of this water for sprinkling, stating that the roads are slippery, and that where there is much traffic the surface is not bound, but is a loose mess, and when winter sets in the salt in the roads rots them, and makes a considerable amount of mud, causing much cleaning and repairs. Besides this there is the deleterious effect of the "glutinous sap" on the flowers and vegetation, which is strikingly apparent in the older seaside towns which have resorted to the use of sea water. Their appearance forms a remarkable contrast to the modern town, with its parades adorned with flowerbeds and shrubs, it tree-lined streets, and its turf-bordered footpaths, in which fresh water is always used for the sprinkling of the roads.—*Journal Gas Lighting.*

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